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THE PHILIPPINE AGRICULTURIST

UNIVERSITY OF THE PHILIPPINES PUBLICATIONS: SERIES A

VOLUME XXV

JUNE, 1936, TO MARCH, 1937
(Complete in ten numbers)

Published by
THE COLLEGE OF AGRICULTURE
UNIVERSITY OF THE PHILIPPINES

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VOLUME XXV

JUNE, 1936, TO MARCH, 1937
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ERRATA

Page 120, line 4 from top, "February 17" should read "March 17."

Page 146, line 10 from top, "*vigna sinensis*" should read "*Vigna sinensis*."

Page 150, legend fig. 1, "*Ceratostomella paradoxa* Dade (*Thielaviopsis paradoxa* (De Seyn Von Hoehnel)" and page 151, legend fig. 2, "(*Thielaviopsis paradoxa* De Seyn. Von Hoehnel)," should read "*Ceratostomella paradoxa* Dade (*Thielaviopsis paradoxa* [De Seyn.] von Hoehnel)"; "*Macrotermis*" should read "*Macrotermes*."

Page 234, line 11 from bottom; page 248, top of page; page 251, line 9 from top; page 252, lines 1, 5, and 15 from top, "*Hospitalitermes hospitalis* (Haviland)" should read "*Hospitalitermes luzonensis* (Oshima)."

Page 367, line 12 from bottom, "₱.63" should read "₱7.63"

Page 471, line 15 from top, "*Panicum barbinode Trin.*" should read "*Panicum barbinode* Trin."

Page 566, legend of fig. 1
Page 568, lines 1 and 4 from bottom } "*Orymoglossum*" should read "*Drymoglossum*."

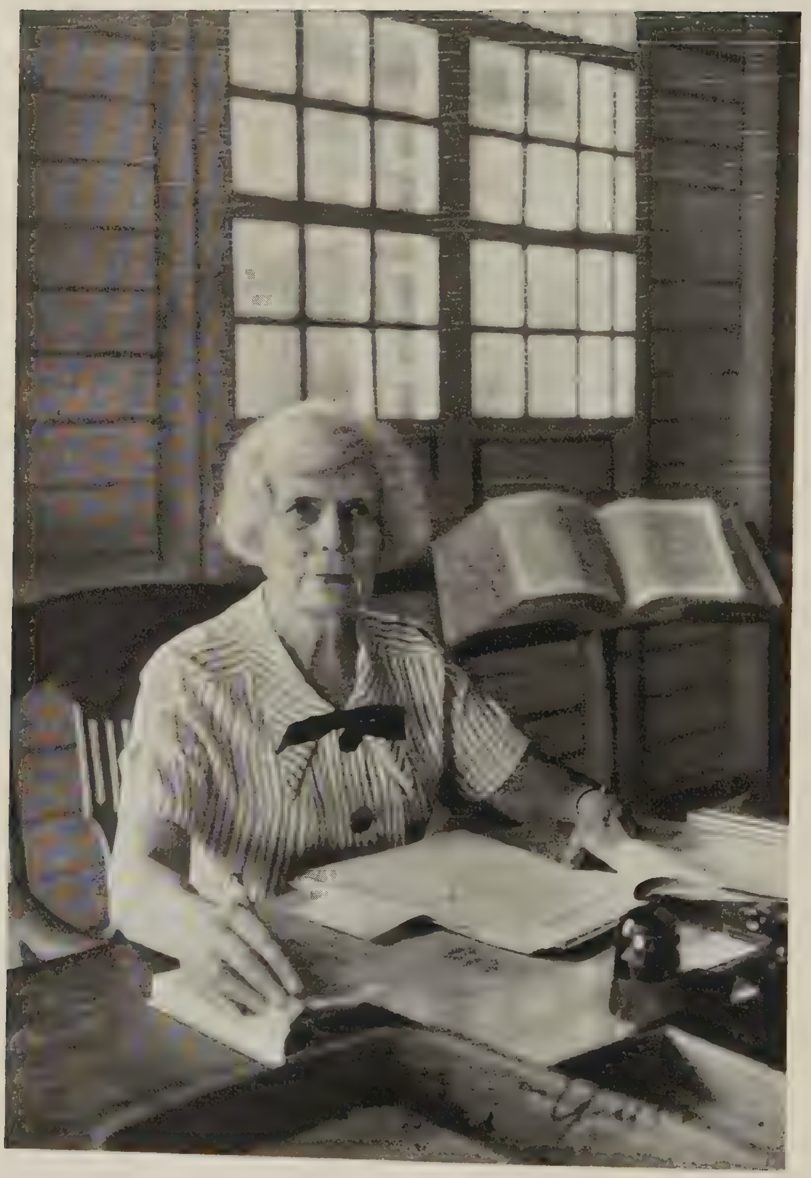
Page 567, legend of fig. 2
Page 568, line 3 from bottom } Dr. E. B. Copeland (*in lit.*) doubts correctness of identification of *Dryopteris*, which he says, is rarely epiphytic. Probably *Davallia*, according to him.

Page 573, line 9 from bottom, "Bukidnon" should read "Davao."

Page 584, line 17 from top, "oranges, which is" should read, "oranges, which are."

Page 681, line 12 from bottom, "MATERLIALS AND METHODS" should read "MATERIALS AND METHODS."

Page 683, line 7 from top, "77–82 ± 16.17 days" should read "77.82 ± 16.17 days."



EMMA SAREPTA YULE
Professor of English emerita
Head of the Department of English, 1915–1936
Assistant Editor, The Philippine Agriculturist, 1919–1925
Editor, 1925–1936

LOOKING INTO THE FUTURE[1]

The Philippine Commonwealth being now a *fait accompli*, the serious problem of making it a successful venture faces every thinking and responsible citizen. The Filipino people have been trained gradually to assume the responsibility for the conduct of affairs under the new order. If training alone in details is an adequate preparation for the task, there need be little fear as to the outcome of this novel experiment in government, where a conquering nation voluntarily relinquishes its authority over a subject people.

There is one phase of government activity, however, wherein the extent of the preparation cannot be considered as adequate, that is, the preservation of the country from outside aggression and internal turmoil. This inadequacy is due to the fact that the sovereign power has assumed largely this responsibility heretofore. To maintain order and be prepared for defense is an undertaking of such great importance and magnitude as to more than likely overshadow the less spectacular phases of government activity. Far be it for any patriotic citizen to deny any honest effort to preserve the integrity of the country through the organization of armed forces. At the same time, sound statesmanship dictates that the security and well-being of a nation depends on a number of factors, not the least of which are those concerned with the material necessities of life.

Were we to analyze, even superficially, the basic causes of aggression, unrest, and rebellion in the world at present, we would realize that they are largely material, revolving around the needs of the people for food and everyday protection from the weather. Given an adequate supply of these necessities, it is easy for nations and their populations to be not only contented but even generous and charitable toward their neighbors. It follows, therefore, that one way of preserving peace internally is to keep the people well fed and adequately clothed and sheltered. Once these basic necessities are provided for, it will be much easier to cultivate the more altruistic sentiments of patriotism, religion, and culture; and enough energy will be held in reserve to be drawn upon for national defense and protection. We are still face to face with the fact that "armies travel on their stomachs".

---

[1] General contribution from the College of Agriculture No. 524.

As the resources of the country are largely agricultural, provisions for their gradual and steady development should not be neglected constituting as they do the basic safeguards for the security of this young nation.

B. M. GONZALEZ
Dean, College of Agriculture

EMMA SAREPTA YULE'S EXPERIMENT STATION CONTRIBUTION NUMBER[1]

Miss Yule's retirement as professor emerita of English and head of the Department of English in the College of Agriculture became effective at the end of the academic year 1935-1936. Thus would the last entry in the cold, unfeeling official files record the close of nearly a quarter of a century of distinguished public service of an American teacher in the Philippines. Theoretically, of course, public service is a beautiful idealism where the individual is submerged in the integrated pattern of a great social machinery.

But Miss Yule's rôle on the faculty of the College of Agriculture was unique and outstanding. She was assuredly more than a mere standardized unit in an educational system. Nominally, her duty was to teach English. She taught English ably and effectively. But there have been scores of other able and effective teachers of English. Miss Yule's constructive work radiated beyond the confines of her classroom. In addition to her rather heavy teaching load, she shouldered equally burdensome extracurricular activities with contagious zeal. In 1919 she was appointed one of the editors of the *Philippine Agriculturist*. Characteristic of her natural adaptability, she accepted the assignment, with some misgivings perhaps, owing to her lack of technical training in agriculture; but she approached the task in a spirit of hopeful optimism. Washington Irving once wrote, "If I cannot get a dinner to suit my appetite, I endeavor to get an appetite to suit my dinner." Miss Yule did better than that. After orienting herself in the hieroglyphics of technical symbols and ponderous scientific language, and it did not take her long to do so, she set about the almost forbidding task of making the *Philippine Agriculturist* suit her sensitive literary taste. She worked hours on articles submitted, painstakingly transposing phrases, deleting a word here or adding a word there, inserting punctuations where these would lend clarity to expression, or sympathetically piloting the budding author through the tricky maze of English idioms.

It is often regretted that scientists are about the only people nowadays who have something to say but do not know how to say it.

---

[1] General contribution from the College of Agriculture No. 525.

Too many of them have either not acquired the knack or have developed a suspicious abhorrence for artistry of language in technical writing, with the result that their message reaches only a limited circle of their colleagues. One often searches in vain in scientific books and periodicals for authors who, in the words of John Masefield, observe that "the acquisition of knowledge, the accumulation of fact, is noble only in those few who have that alchemy which transmutes such clay to heavenly eternal gold.... We moderns," he laments further on, "who care little for any tree so soon as we can murmur its Latin name, have lost wonder in losing faith."

The twenty-fourth volume of the *Philippine Agriculturist* which closed last March was the last of seventeen that bore the stamp of Miss Yule's editorial guidance. Quite aside from their unquestioned importance as probably the most exhaustive collection of original contributions to knowledge of Philippine agriculture, the series represents a set of documents in contemporary history that portray evolutionary steps in technical writing by Filipinos. It shows how, like other people, Filipino scientists, after being shown the way by competent direction, can attain at least some measure of success in writing, not only intelligibly, but also interestingly, on their special subjects in the English language. The experiment station contributions from the College of Agriculture now number 1111. Miss Yule's name does not appear on any of these. But the subdued tones and tastefully apportioned highlights, the harmonious arrangement of color which brings vividness to descriptions and makes the reader catch passing glimpses of fugitive suggestions, all this and many more make as almost a perfectly balanced canvas of each technical article as can be attained only through the magic touch of the master stylist.

LEOPOLDO B. UICHANCO
Managing Editor

EMMA SAREPTA YULE, ON HER RETIREMENT[1]

It has been said that "man is a creature so full of potentialities, some for good, some for evil, and all so confused and contradictory, that unless he is shown by his educators just what potentialities he ought to develop and what to leave undeveloped, he does not really live, he is just a bundle of confused strivings, incapable of sustained achievement." One of the aims of education, therefore, is to make man achieve something, primarily for the sake of himself, secondarily for the sake of whatever culture he has inherited. Its practical object is that of showing man what he can do with his inherited tendencies under his given environment.

Imbued with an intense desire to help educate man and aid him in making the most out of his inherited tendencies under different sets of environmental conditions, Professor Emma Sarepta Yule, retiring member of the faculty of the College of Agriculture, has made teaching her life work. Born of pioneer farmer stock of Iowa, Professor Yule has remained true to the tradition of her family; she had always been a pioneer in her chosen career. She has never stepped into an established job. Her first professional task was to place and put in running order a normal school course in an academy in northwest Iowa. Then on to Puget Sound where new opportunities were offered in a new industrial townsite. She was appointed next to start the school system in this new town, Everett, Washington. Today, the school records state that Emma Sarepta Yule was the founder and first Superintendent of Schools in Everett, Washington. When everything was running well and the school was one of the "Big Four" in the state, Miss Yule resigned and went to Juneau, Alaska, a newer frontier, and organized the first public school in the territory. In four years this high school was on the accredited list in the University of Washington.

Did Miss Yule linger in Alaska after the organization work was over? No. Upon hearing that unlimited opportunities for pioneering work abounded in the Philippines, out she went to this country which was then practically unknown to most Americans. That was in 1910, more than a quarter of a century ago! Here Miss

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[1] General contribution from the College of Agriculture No. 526.

Yule became a teacher of Philippine economics in the then Manila High School, the only Government high school in Manila at the time. She was with this school from January, 1910 to March, 1914. Miss Yule, under special appointment in the Bureau of Education, was in the Department of Mindanao and Sulu when this Department was first organized. Even in these two places Miss Yule stayed only long enough to get the work she started going well.

A strong pioneering instinct must have been in the blood of this energetic Iowan, for we next find her in the College of Agriculture, which she joined in January, 1916. Her first work was to strengthen our Department of English. The writer happens to be acquainted with the first curriculum of the College, and he also knows how English was taught here in those days when this institution was still in its swaddling clothes. Miss Yule, because of her many years of experience in this kind of work, must have found really enjoyable the task of reorganizing, or shall we say organizing, the Department of English. Without any fuss she took up the work as she found it, cheerfully and with the most genuine interest. She gave a large amount of time and thought to devising work and courses that would be specially and peculiarly adapted to the particular needs of the College. For this reason, it was not many years after Miss Yule joined the faculty when real "agricultural" courses in English were being offered in the curriculum of this College.

Professor Yule is one of the hardest working members of the faculty of the College of Agriculture. In addition to her duties as professor and head of the Department of English, she was given the charge of editing *The Philippine Agriculturist,* the official repository of all the results of studies made in the College for the advancement of Philippine and tropical agricultural science and the improvement of Philippine agriculture. Editing our College Journal, as the members of the faculty of this College know, includes the careful reading of both the galley and the page proofs. Professor Yule, more than anybody else, has been responsible for the exceptionally high standard that has been maintained in *The Philippine Agriculturist.* This journal is at present equalled by no other journal along the same line published in any part of the world.

Professor Yule has also been called upon to edit practically every manuscript issued by the College whether published in the official publication or in other journals both local and foreign. She also reads for English the different theses that are submitted by the seniors as a requirement for their graduation. All of this work has been done in the most cheerful spirit and with an attitude that invites for more work.

Professor Yule is one of the permanent workers of this institution, one whose interest in the College and all that pertains to it is genuine. She has given to the institution and to its students the best that is in her ability. Surely, the College owes much to her. Her retirement leaves a void in the faculty which will be difficult, if not impossible, to fill.

The faculty of the College of Agriculture fully recognizes all that Professor Yule has done for the College, the institution in which she has spent some of the best years of her life; the institution in which she has cast her lot in spite of more remunerative opportunities elsewhere. For all this the faculty will long remember Miss Yule. At the last faculty meeting that she attended as an active member, her colleagues presented to her a remembrance, something that she will surely enjoy gazing at after she leaves the College Campus, just as she must have gazed at the view it contains in moments of relaxation after a day of strenuous work. This gift will be everlasting and it is hoped it will frequently refresh her memory and call to her mind the many years of fruitful work that she has spent in this College. Professor Yule can rest assured that the present is given with affection by her associates and her many admirers in this College.

The writer is especially happy that he should have been the one privileged to present for his colleagues in the faculty of this College this gift to Professor Yule. It is one of his rare sources of pride to be able to point out that he was one of the members of one of Miss Yule's first classes in English III. He counts himself among the many who recognize and have valued her services to the College. For these reasons, this special occasion is one that he shall never forget.

F. M. Fronda
Secretary, College of Agriculture
and Associate Professor of
Poultry Husbandry

A RESOLUTION OF THE FACULTY OF THE COLLEGE OF AGRICULTURE

WHEREAS Miss Emma Sarepta Yule is soon retiring from the chair of professor of English and head of the department of English, at the College of Agriculture, which she has occupied for almost two decades;

WHEREAS for many years, in her successive capacities as assistant editor, editor, and managing editor of *The Philippine Agriculturist*, and in the constructive spirit in which she has gone into the patience-taxing work of correcting for English and style manuscripts submitted for publication by students and faculty, to whom English is not a mother tongue, she has done a most important work in elevating the standard of our scientific contributions and has in this respect been instrumental in enhancing the prestige of the College of Agriculture in the learned world;

WHEREAS in the faithful and efficient performance of her duties, during and outside regular office hours, and in her unselfishly helpful relations with her fellow teachers, students, and the community at large, she has in no small way helped breathe into our social and scholastic life high ideals of public service, devotion to duty, sympathetic understanding, tolerance, and other essential ingredients that make for wholesome growth in a nation's body of citizens; now therefore be it

RESOLVED that the Campus community will ever treasure pleasant and grateful memories of a dear friend and colleague, with whom to associate was a privilege and whose counsel, an inspiration that we will all painfully miss hereafter; and be it further

RESOLVED that this resolution be engrossed and presented to Professor Yule and that a copy be sent to *The Philippine Agriculturist* for publication.

APPROVED at the twenty-seventh regular meeting of the faculty of the College of Agriculture on this twenty-fourth day of March, nineteen hundred and thirty-six.

A STUDY ON THE BREEDING HABITS OF GOATS[1]

GAVINO C. ARRIOLA

It is important for the animal breeder to know the breeding habits of his animals. This knowledge will be useful mainly in increasing the reproductive ability of the animals.

PAST WORK ON THE SUBJECT

According to Shaw (1918) (1) uneasiness and (2) constant shaking of the tail are signs of heat, and a doe usually remains in heat from one to two days. Richards (1921) gives the following indications of oestrus in the doe: (1) twitching of the tail, (2) redness of vulva, (3) restlessness and noisy bleating. Asdell (1926) states that the duration of oestrus varies from one to three days. The same author, citing Drummond—Robinson and Asdell, further states that ovulation among does is spontaneous, occurring without external influence.

The does are usually in heat once about every twenty-one days according to Richards (1921). Shaw (1918) reports that the interval between heat periods varies from five to twenty-one days, and that records of the Bureau of Animal Industry of the United States Department of Agriculture show that the majority of the does returned to heat in from five to seven days. Those that exceeded this time usually came in heat in from eighteen to twenty-one days. Asdell (1926) reports that the breeding season of the goat under conditions obtaining in England consists of a series of dioestrous cycles with a duration of about twenty-one days. Voorhies (1918) states that in California the doe usually comes in heat once every three weeks, except in July and August.

Villegas (1932) reports that, according to the records at the College of Agriculture, the does may breed from 6 to 92 days, or an average of 46 days from the time of the last parturition.

Regarding the period of gestation of goats, Richards (1921) states that "the normal period of gestation is usually said to be 150 days. It is not infrequently less than this by several days, the normal birth of vigorous kids occurring at 146 or 147 days. With the large Swiss goats, however, it occurs even more frequently that birth is delayed to 152 days or 154 days." Asdell (1929) studied data from the kid register of the British Society, which includes the Anglo-Nubian, Toggenburg, a few Saanen and English breeds. From a total of 6,342 cases he found that the length of gestation periods varied from 107 to 200 days, the mode being 151 days with 891 cases. From this study, the same author made the following conclusions: "Slight breed differences were found to exist in the length of the gestation period. Pregnancies arising from spring conceptions were of shorter duration than those taking place during autumn. The gestation period was shorter for the younger than for the older ones, but the size of the litter had little or no effect." Defining gestation as the time between the effective service of the buck and the birth of kids, Shaw (1918) reports that this time ranges from 146 to 152 days, or practically 5 months. He also reported that the average gestation period for several years in the Bureau of Animal Industry, United States Department of Agriculture, herd with does of several types had been 149 days. Voorhies (1918) reported that the duration of pregnancy in does is about 152 days. Thompson (1908) gives the average period of gestation for sheep and goats as five months, or from 20 to 22 weeks. Villegas (1932), from figures based on records of the College of Agriculture, reported that the average period of gestation among does was 149 days. Cunningham (1926) gives the average period of gestation for goats as 152 days, or approximately 5 months. Matthews and Weaver (1928) give the gestation period of goats as about 150 days. Hinterthur (1933), from the record of 391 does of the fawn Schwarzwald breed, reported that the duration of pregnancy varied from 124 to 168 days, with a mean of 150.8 ± 0.19 days.

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[1] Thesis presented for graduation, 1933, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture No. 490; Experiment Station contribution No. 1112. Prepared in the Department of Animal Husbandry under the direction of Dr. Valente Villegas.

According to Villegas (1928), goats register yearly peaks of sexual activities, during May and June and from November to February. The kidding season starts in April and covers a period of four months or until July; it begins again in October and ends in December.

OBJECTS OF PRESENT WORK

The objects of the present work were to determine the following in the doe: (*a*) signs of eostrus, (*b*) duration of oestrus, (*c*) recurrence of oestrus, (*d*) age at first oestrus, (*e*) interval between parturition and next breeding time, (*f*) signs of pregnancy and approaching parturition, (*g*) gestation period, (*h*) time of day most favorable for mating, (*i*) behavior of buck and doe at breeding time, (*j*) correlations between weight of does and gestation period; between interval of parturition and first oestrus and total milk production; between weights of dam and weights of kids; and between age of does and gestation period.

TIME AND PLACE

This study was conducted in the College of Agriculture, University of the Philippines, Los Baños, Laguna. The work was begun on October 28, 1931 and closed on September 6, 1933, covering a period of 1 year and 10 months.

MATERIALS AND METHODS OF PROCEDURE

Materials

Does. Grade Anglo-Nubian does of varying ages, which belonged to the College of Agriculture, and one Native doe owned by a private person were used in this study (see table 1).

Bucks. The College buck, an Anglo-Nubian grade, of mature age and weighing 49.5 kgm. at the beginning of the experiment was used to breed with the does studied in this work. Another buck, also an Anglo-Nubian grade, was vasectomized[2] and was used to determine the duration of oestrus and intervals between oestral periods. The same buck was also used in determining the behavior of buck and doe when put together during oestral period. Both bucks were healthy, vigorous and aggressive.

Barn. The barn in which the goats were housed at noon and during the night has a concrete floor to facilitate cleaning. It was built so that the animals are protected from strong drafts and the pens are kept warm at night by wooden walls around them; sufficient ventilation is provided through the openings at the top and bottom. The roof is made of galvanized iron. Strong partitions between pens are provided so as to keep the different classes of animals under control, with particular regard to mating. Racks for feeding and salting are built in each pen. Likewise, a watering tank is available.

Feeding and management of does

The does were driven to pasture with the general herd in the morning and afternoon. At noon and in the night they were kept in the barn, mainly for shelter. Occasionally, when the rain was continuous and hard, the animals were kept in the barn the whole day. At night the animals received additional feed in the barn. Either Napier or Guinea grass was put in the racks and when the weather was unfavorable grain was fed in amounts that they would consume readily at each feeding. The grain mixture consisted of 5 parts, by weight, of shelled corn, 3 parts of copra meal and 2 parts of rice bran. The milking does were given grain every night and the allowance was more liberal. Clean drinking water and common salt were made available for the animals at all times.

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[2] Dr. M. Manresa of the Department of Animal Husbandry of the College of Agriculture performed the operation of vasectomy on the buck.

Every doe that kidded was separated from its herd and left with her young unmolested during the first three days to enable the kid to suckle the first milk or colostrum. On the fourth day the dam was separated from her young from 1:00 p. m. till 6:00 a. m. the following day when she was milked. Both the kid and the dam were put together in the barn in the morning so the kid could be free to suckle its mother. This practice was followed up to weaning time when the kids were about six months old.

Management of buck

To keep the buck in good condition for breeding purposes and to prevent promiscuous matings he was kept and fed separately in a pen by himself. Every day, morning and afternoon, he was given a generous supply of the grain mixture used for the does. In addition, he received a supplement of mungo grain. Napier grass, a very palatable roughage (Suratos, 1932) was also given to him. Clean drinking water and common salt were supplied to him at all times. The vasectomized buck received the same feed as that given the breeding buck and was also kept in a pen by himself. Both bucks were taken in the morning or in the afternoon to the paddock for sun bath and exercise.

Method of breeding

With the entire buck the method of breeding used was as follows: The buck was turned loose with the open does in the general herd daily from four to five o'clock in the afternoon; sometimes this was done in the morning, also. Within about one hour after the buck had been placed with the females it was observed that he was able to locate the does that were in heat. As soon as a doe in oestrus was recognized by the buck, mating took place immediately. If more than one doe was in oestrus at the same time the one that had been served by the buck was at once separated from the herd so that he would give his attention to the other does that were also in oestrus. A doe that had been served was not put with the buck until about a month after the mating at which time she was again allowed to be bred by the buck. Such an interval between matings was judged to be necessary to determine the exact period of gestation.

The buck was put with the doe daily from the date of kidding until the doe came in heat. In this manner the interval between parturition and the first oestrus following was determined.

To determine the recurrence of oestrus, duration of oestrus, and the different activities shown by the buck and doe when the latter was in heat, the vasectomized buck was used to prevent the fertilization of the doe at mating. It is evident that the period during which the does would receive the buck indicated the period of oestrus, and from the time the doe ceased to accept the buck till the beginning of the next oestrus was taken as the interval between oestri. To determine such interval the same buck was brought to the open does daily morning and afternoon till oestrus manifested.

It is a common belief that goats under an uncontrolled system of breeding breed at any time. Also, it seems to be the opinion that the buck will cover a doe in oestrus continuously until he is exhausted and no longer able to mount. Having those beliefs in mind, constant observations were made on the breeding activities of the buck and doe in oestrus, using the vasectomized buck. For this purpose the procedure described below was followed: As soon as a doe was found to be in oestrus, she was put in a separate pen with the vasectomized buck. Observations were made constantly over their activities throughout the period of oestrus. During the night a lamp was used to enable the observer to see the activities taking place. Care was, however, taken so that the animals were left to themselves unmolested as far as possible. This study yielded data on the following phenomena: (1) duration of oestrus, (2) manner of exciting the doe, (3) mounting the doe, (4) mating, (5) rest and (6) behavior of the doe immediately after mating.

DISCUSSION OF RESULTS

Observations on the breeding activities of buck and doe during the period of oestrus

Period of oestrus. As may be seen in table 2 the actual period of oestrus among the five does observed varied from 12 hours and 34 minutes to 23 hours and 49 minutes, with an average of about 18 hours. In this case, observation was made at all times during oestrus.

Oestrus was observed to appear in both the morning and afternoon with the greater number of cases in the afternoon. Twenty-four of the cases were observed to start in the afternoon and seventeen in the morning. More oestri also ended in the afternoon than in the morning. When the does were observed during the daytime, only, the approximate duration of oestrus varied from 1 to 4 days the average of 33 cases being 1.62 days (table 3). There was only one case of a 4-day period of oestrus, and this may be considered an exception. About 97 (96.9) per cent of the cases took place between one and three days. This observation agrees closely with the findings of Asdell (1926). The period of oestrus lying between one and two days constituted 90.9 per cent of the total. Shaw's (1918) findings are in agreement with this result. About six (6.06) per cent lay between two and three days and about three (3.03) per cent, between three and four days.

Exciting the doe. Examining table 2, it may be noted that the buck did not excite the doe at all times throughout the oestral period. It may be seen that the buck caressed doe No. 265 most frequently during the early part of the observations continuing toward midnight and only once in the morning. It was seen also that the buck teased doe No. 103 only in the morning. The buck excited does Nos. 281, 195 and 314 about the same in the afternoon as he did during the following morning. There was a tendency for the buck not to approach the doe toward midnight and during the early part of the morning.

Buck mounting the doe. It may be seen in table 2 that the buck mounted the doe immediately when in heat and continued to do so for some time.

Matings. Table 2 shows that most of the matings took place during the early part of the observations. That matings took place during the night may be seen with does Nos. 265 and 314. It seemed that the aggressiveness of the buck, which apparently had diminished as a result of previous matings, was renewed after a period of rest. That individual preference for a particular female occurs among goats is indicated in the table, which shows that of two does, Nos. 281 and 103, both in heat, No. 281 was served more frequently than No. 103. It was also observed that when the doe was no longer in heat it could not be served.

Rest. It may be noted in this table that both the buck and doe rested either lying down or in a standing position during the teasing and mating period. The buck lay down as often as from six to ten times, the doe from three to seven times.

Urination of does immediately after mating. As may be seen in table 2, out of 20 matings 9 cases showed urination of does immediately after mating. Doe No. 103 was served twice but did not urinate soon after mating.

Age at first oestrus

Data concerning the age at which first oestrus appears is of value to the animal breeder, particularly with reference to the age at which the young females are to be separated from the buck to prevent early breeding.

The age at first oestrus of the five does which were observed varied from 315 to 574 days, the average being 494 days.

Indication of oestrus

Examining quietly but carefully does in oestrus, the following indications were sometimes observed: (1) restlessness as indicated by a change in their behavior, particularly at the approach of man; (2) slight swelling of the external genitalia, accompanied by a slightly marked opening and closing of the lips of the vulva and a slight change in the color of the mucous membrane lining it, that is, from pale pink to reddish pink, (3) regular but slightly marked contraction and relaxation of the external genitalia accompanied, sometimes, by an up and down movement of the tail; and (4) the moist appearance of the external orifice of the vulva. However, all these symptoms described were not always observed among does in oestrus.

When the buck was turned loose in the herd he was observed to locate readily does in oestrus, probably guided by a characteristic odor given off by them. As the buck approached, additional indications of oestrus were shown by the doe. These were: (1) rapid shaking of the tail sideways as the buck excited the doe; and (2) quietness or greater docility accompanied by slight goring as a signal, perhaps, of desire for mating. Immediately after coitus the formation of a thick and white mucoid substance was observed to hang from the genital orifice. Such mucoid material was also observed even after the service of the vasectomized buck which, as contrasted from the breeding buck, could not eject fertile semen because of the severance of the vas deferens. Microscopic examinations of this substance taken after the service of the fertile buck revealed the presence of numerous motile spermatozoa, whereas no spermatozoa, either motile or non-motile, was found in samples taken after the service of the vasectomized buck. Apparently, this material is made up of the secretions of the accessory sex organs like the prostate gland, bulbourethral gland and Cowper's gland.

Close observation of the does used in this study showed variability in their behavior while in oestrus. Some does, particularly the less docile ones, would accept the buck without showing apparent indications of oestrus. However, all of them invariably exhibited the presence of a mucoid substance which was seen to drop from the external genitalia after breeding. Also, the wagging of the tail was observed in all of them. That intergeneric mating occurs was shown by does Nos. 103, 173, 193, 203, 281, 290, and 314 which accepted the ram as willingly as they did the buck and the signs of oestrus were practically identical whether they were bred by the buck or by the ram. That these services were not fertile in any of the does served by the ram is shown by the appearance of the resulting progeny. It was observed that some of the does would even approach the buck previous to mating; this was, however, not true with the majority of them. None of the does was observed to mount another doe or buck; neither was there any marked change in their appetite during the oestral period, as is the case with cattle (Diapo, 1933).

Interval between oestri

According to table 3, the interval between oestri varied from 4 to 44 days with a mean of 10.20 days. About 79 (79.31) per cent of the cases lay between 4 and 10 days with a mode of 5 (4 to 6) days. As to whether ovulation took place at shorter intervals than shown by the results was not determined. The results showed that when the interval between oestri exceeded 10 days, the tendency was for the interval to become longer and more irregular in duration. That is, the interval varied from 21 to 44 days. With the exception of the 4-day interval, on the whole, the results seem to agree closely with the work of Shaw (1918) who reported that the greater number of does returned to heat in from five to seven days, and that animals that exceeded this time usually came in heat in from 18 to 21 days.

Signs of pregnancy and approaching parturition

Observations were made on 27 does regarding these points. Shortly after impregnation no marked signs of pregnancy were noticed, with the exception of the cessation of oestrus. Toward the second month of pregnancy there was slight indication of the does laying on fat, this being accompanied by very slight distention of the udder in the case of dry does. As they approached the third month of pregnancy, the indications appeared fairly marked to the observer. The belly began to distend downward accompanied by a slight sinking of the muscles in the rump. These symptoms of pregnancy became more marked in the fourth month. Examination of the monthly weight of those does, as shown in table 5, revealed that the gain in weight was consistent, ranging from an average of 2.36 to 3.17 kgm., the highest gain being in the fourth month. The distention of the belly and the udder became more pronounced and the sinking of the muscles at the rump deeper than before. At this time, the udder and belly were well distended, vulva swollen and the milk veins very prominent.

The signs of approaching parturition observed were as follows: (1) Very sudden distention of the abdomen assuming almost a horizontal position from the udder to the middle of the belly; (2) sudden distention of the udder, its form becoming rounded; (3) full sinking of the muscles at the rump particularly at the base of the tail, making the sacrum and the base of the tail appear like a ridge; (4) full swelling of vulva. Just a short time before parturition the does appeared very restless, bleating as if calling for help. They pawed the ground and tried to isolate themselves from the herd. The vulva and the ends of the teats were dry at this time. Then a violent movement of the fetus was observed on both sides of the abdomen. At this time the doe began to take a recumbent position, stood up and moved around, but soon lay down again. Also, at this time the tail was observed to move downward and upward as if the animal would defecate. Frequent and loud bleatings were heard, followed usually by the sudden expulsion of the young.

First oestrus after parturition

The interval between parturition and the first oestrus of does, as may be seen in table 4, showed great variability. It varied from 8 to 276 days after parturition, the mean of 41 cases was 91.48 ±

8.088 days. Eighty-eight (87.80) per cent of the total came in oestrus for the first time between 8 and 139 days after parturition, of which 55 per cent came in heat within 20 to 40 days.

Period of gestation

The period of gestation observed varied from 139 to 159 days, the mean of 27 cases was 148.11 ± 0.6743 days. Eighty-five (85.18) per cent of the total lay between 143 to 151 days, with a mode of 149 days. This figure is in close agreement with the finding of Shaw (1918) and with that reported by Villegas (1932).

It was found in this study that fertile matings among goats occurred irregularly throughout the different months of the year. November, however, had the highest frequency of fertile matings. Also, kidding took place throughout the year, the highest occurring in April. No conclusions can, however, be made regarding this point on account of the limited data obtained.

Correlation studies

Between the weight of does and the length of gestation period. From the data obtained there was a small but insignificant positive correlation, the coefficient being 0.28 ± 0.122, indicating that the length of gestation period was not influenced by the weight of the does at kidding time.

Between interval from parturition to first oestrus and total milk production. Table 5 shows a fairly high correlation between the interval from parturition to first oestrus and the total milk production.

There was a positive correlation coefficient of 0.45 ±0.089. That is, the greater the amount of milk produced the longer the interval between parturition and first oestrus in does. This might be accounted for by the fact that the more milk produced the greater was the drain on the body of the animal and therefore the greater was the chance for her to be out of condition for breeding.

Between weight of dam and weight of kids born. The correlation between the weight of the dam and the weight of the kids born was positive with a coefficient of 0.52 ± 0.081. It is significant that the heavier dams produced the heavier kids.

Between the age of does and period of gestation. According to Asdell (1929), the gestation period among does was shorter for the younger than for the older ones. From the data obtained in this study a positive but insignificant correlation was found between the age of the doe and the length of gestation period, the coefficient being 0.16 ± 0.125.

SUMMARY OF CONCLUSIONS

From the preceding discussion the following conclusions are drawn:

1. The period of oestrus when does were observed at all times during oestrus was on an average about 18 hours.

2. Goats during the oestral period exhibited variability in their sexual manifestation. The buck excited and mounted the doe more during the early period of oestrus. Matings took place as many as six times during oestrus. In about half of the cases the does urinated immediately after coitus. It was observed that buck and doe rested the greater part of the time during oestrus; they were observed to rest in lying down more than in a standing position. The buck was not found to breed does no longer in heat.

3. The age at first oestrus was between 518 and 374 days, the mean being 494 days.

4. The following were the marked manifestations of oestrus found in all does: (1) rapid sidewise motion of the tail as the buck excited the doe, and (2) immediately after coitus the formation of a white thick mucoid substance which hung from the genital orifice. Other signs of oestrus, in addition to those mentioned above, exhibited by some does were: (1) restlessness, (2) swelling of the vulva and a slight change in color of the mucous membrane lining it from pale pink to reddish pink color, (3) regular but slightly marked contraction and relaxation of the external genitalia and (4) slight change in the appearance of the external orifice of the vulva as if moist.

5. The interval between oestri was 10.20 days. It appeared that when the interval between oestri exceeded 10 days, the tendency was for this interval to become longer and more irregular in duration, that is, 21 to 44 days. It was not determined whether the occurrence of the so-called oestri of shorter duration than 21 days was accompanied by ovulation or not.

6. The indications of pregnancy and approaching parturition were: (1) continued cessation of oestrus after breeding; (2) consistent gain in weight from conception to the end of pregnancy; (3) sudden distention of the udder, belly and full swelling of the vulva; (4) sinking of the muscles at the rump making the sacrum appear

like a ridge; (5) tendency to separate from the rest of the herd; and (6) labor pains and frequent bleating of doe accompanied by the violent movement of the fetus followed generally by sudden delivery of the young.

7. The interval between parturition and the first oestrus of does varied from 8 to 276 days, with a mean of 91.48 ± 8.088 days. Eighty-eight per cent were between 8 and 139 days of which 55 per cent were within 20 to 40 days.

8. The period of gestation of does varied from 139 to 159 days with a mean of 148.11 ± 0.674 days.

9. There was a positive but insignificant correlation between the weight of does and the length of gestation period ($r = 0.28 \pm 0.122$).

10. There was a fairly high positive correlation ($r = 0.45 \pm 0.089$) between the interval between parturition and first oestrus and the total milk production during such period, indicating a reciprocal relationship.

11. A high and significant correlation ($r = 0.52 \pm 0.081$) between the weight of the dam and the weight of kids born was found.

12. There was no significant correlation ($r = 0.16 \pm 0.125$) between the age of does and the gestation period.

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TABLE 1

Showing the breeding, date of birth and weight of animals used in this experiment

HERD NO. OF ANIMALS	BREEDING	DATE OF BIRTH	WT. AT BEGINNING OF EXPERIMENT
does			*kgm.*
37	Indian grade	Unknown (very old)	32.7
70	Indian grade	21-XII-'23	37.7
78	Indian grade	5- VI-'24	22.7
96	Indian grade	10-XII-'24	25.0
103	Indian grade	28- I-'25	28.3
130[a]	Indian grade	Unknown (old)	33.6
144	Anglo-Nubian grade	23- IV-'26	27.3
164	Anglo-Nubian grade	23- X-'26	33.6
173	Anglo-Nubian grade	30-XII-'26	25.9
180	Anglo-Nubian grade	24- IV-'27	37.7
193	Anglo-Nubian grade	11- XI-'27	32.7
195	Anglo-Nubian grade	12- XI-'27	37.7
203	Anglo-Nubian grade	19- XI-'27	30.5
204	Anglo-Nubian grade	23- II-'28	21.8
231	Anglo-Nubian grade	11- X-'28	27.3
234	Anglo-Nubian grade	13- X-'28	35.5
235	Anglo-Nubian grade	17-XII-'28	22.7
236	Anglo-Nubian grade	17-XII-'28	24.1
265	Anglo-Nubian grade	2- X-'29	19.5
275	Anglo-Nubian grade	26- V-'30	18.2
276	Anglo-Nubian grade	27- III-'30	20.5
281	Anglo-Nubian grade	28- III-'30	20.5
288	Anglo-Nubian grade	8- IX-'30	19.5
306	Anglo-Nubian grade	15- I-'31	13.6
314	Anglo-Nubian grade	15- III-'31	14.1
318	Anglo-Nubian grade	24- III-'31	7.3
Unnumbered[b]	Native	—	—
bucks			
176	Anglo-Nubian grade	19- II-'27	49.5
304	Anglo-Nubian grade	13- I-'31	13.6

[a] This doe appears to be still in prime of age for breeding purposes.
[b] According to her size and appearance she is relatively young.

TABLE 2

Showing the time and frequency of important activities of breeding goats that took place when observed constantly during period of oestrus in does

HERD NO. OF DOE	BEGINNING OF OESTRUS	END OF OESTRUS	BUCK EXCITING DOE	BUCK MOUNTING DOE	MATING
265	5:00 p. m. (17-XII-'32) Period of oestrus (17 hrs., 06 min.)	10:06 a. m. (18-XII-'32)	Period: 5:38 p. m. to 5:20 a. m. Frequency: 12 times.	Period: 5:30 p. m. to 11:58 p. m. Frequency: 3 times.	Period: 5:34 p. m. to 11:58 p. m. Frequency: 3 times.
281	4:30 p. m. (19-XII-'32) Period of oestrus (12 hrs., 34 min.)	5:04 a. m. (20-XII-'32)	Period: 8:23 p. m. to 5:20 a. m. Frequency: 8 times.	Period: 5:05 p. m to 5:20 a. m. Frequency: 6 times.	Period: 5:07 p. m. to 9:57 p. m. Frequency: 6 times.
103	4:30 p. m. (19-XII-'32) Period of oestrus (18 hrs., 38 min.)	11:08 a. m. (20-XII-'32)	Period: 5:09 a. m. to 10:05 a. m. Frequency: 2 times.	Period: 5:09 a. m. to 7:34 a. m. Frequency: 2 times.	Period: 5:10 a. m. to 7:41 a. m, Frequency: 2 times.
195	4:00 p. m. (28-III-'33) Period of oestrus (23 hrs., 49 min.)	3:49 p. m. (29-III-'33)	Period: 7:14 p. m. to 3:49 p. m. Frequency: 9 times.	Period: 5:00 p. m. to 8:41 a. m. Frequency: 6 times.	Period: 5:00 p. m. to 8:50 a. m. Frequency: 5 times.
314	5:00 p. m. (13-VIII-'33) Period of oestrus (14 hrs., 23 min.)	7:23 a. m. (14-VIII-'33)	Period: 5:28 p. m. to 7:23 a. m. Frequency: 9 times.	Period: 5:00 p. m. to 4:00 a. m. Frequency: 10 times.	Period: 5:27 p. m. to 11:59 p. m. Frequency: 4 times.

TABLE 2 (Continued)

HERD NO. OF DOE	LYING DOWN POSITION		RESTING WHILE STANDING		URINATION OF DOE IMMEDIATELY AFTER MATING
	Buck	Doe	Buck	Doe	
265	Period: 6:02 p. m. to 5:20 a. m. Frequency. 9 times.	Period: 6:02 p. m. to 5:20 a. m. Frequency: 6 times.	Period: 5:34 p. m. to 7:20 p. m. Frequency: 3 times.	Period: 7:27 p. m. to 12:00 p. m. Frequency: 2 times.	11:58 p. m.
281	Period: 6:19 p. m. to 5:04 a. m. Frequency: 6 times.	Period: 6:29 p. m. to 4:45 a. m. Frequency: 6 times.		9:00 p. m.	Period: 5:07 p. m. to 9:57 p. m. Frequency: 3 times.
103		Period: 7:13 p. m. to 11:08 a. m. Frequency: 3 times.	10:30 a. m.	Period: 4:30 p. m. to 7:13 p. m. Frequency: once.	
195	Period: 6:20 p. m. to 3:43 p. m. Frequency: 10 times.	Period: 6:41 p. m. to 1:00 p. m. Frequency: 6 times.	Period: 5:02 p. m. to 3:50 a. m. Frequency: 3 times.	8:07 p. m.	Period: 5:02 p. m. to 8:50 a. m. Frequency: 3 times.
314	Period: 6:00 p. m. to 6:02 a. m. Frequency: 8 times.	Period: 6:21 p. m. to 6:18 a. m. Frequency: 7 times.	Period: 5:27 p. m. to 4:37 a. m. Frequency: 7 times.	Period: 12:00 p. m. to 2:00 a. m. Frequency: 2 times.	Period: 7:03 p. m. to 11:58 p. m. Frequency: 2 times.

TABLE 3

Showing the beginning and end of oestral period, period of oestrus and interval between oestri

HERD NO. OF DOES	OCCURRENCE OF OESTRUS			CESSATION OF OESTRUS			PERIOD OF OESTRUS	INTERVAL BETWEEN OESTRI
	Date	Morning	Afternoon	Date	Morning	Afternoon		
							days	*days*
276	9- III-'32		x	11- III-'32		x	2	—
	19- III-'32	x		21- III-'32		x	2	10
	25- III-'32		x					6
235	10- IV-'32		x	12- IV-'32		x	2	—
	16- IV-'32		x	18- IV-'32	x		2	6
	21- IV-'32	x		23- IV-'32		x	2	5
	27- IV-'32	x						6
265	16- IV-'32	x		17- IV-'32		x	1	—
	22- IV-'32	x		23- IV-'32	x		1	6
	28- IV-'32	x		29- IV-'32	x		1	6
	20- V-'32		x					22
103	22- III-'32	x		23- III-'32		x	1	—
	30- III-'32		x	2- IV-'32	x		3	8
	7- IV-'32		x	10- IV-'32	x		3	8
	9- V-'32		x					32
144	24- IX-'32	x		26- IX-'32		x	2	—
	4- X-'32		x	5- X-'32		x	1	10
	10- X-'32		x	12- X-'32		x	2	6
70	9- X-'32		x	11- X-'32	x		2	—
	15- X-'32	x		16- X-'32		x	1	6
	19- X-'32		x	23- X-'32	x		4	4
	26- X-'32	x						7
314	22-VIII-'32	x		23-VIII-'32		x	1	—
	31- X-'32	x		1- XI-'32		x	1	40
	7- XI-'32		x	8- XI-'32	x		1	7
	13- XI-'32		x					6
180	1- II-'33		x	3- II-'33	x		2	—
	6- II-'33		x	8- II-'33	x		2	5
265	1- VI-'33		x	2- VI-'33		x	1	—
	6- VI-'33	x		7- VI-'33		x	1	5
	20- VII-'33	x		22-VIII-'33		x	2	44
173	24- VII-'33		x					—
	29- VII-'33	x		30- VII-'33		x	1	5
	19-VIII-'33		x	21-VIII-'33	x		2	21
144	31- VII-'33		x					—
	5-VIII-'33		x	7-VIII-'33	x		2	26
	11-VIII-'33	x		12-VIII-'33		x	1	6
	16-VIII-'33		x	18-VIII-'33	x		2	5
314	7-VIII-'33		x	8-VIII-'33		x	1	—
	13-VIII-'33		x	14-VIII-'33	x		1	6
	18-VIII-'33	x		19-VIII-'33		x	1	5

Period of oestrus
M = 1.62 days

Interval between oestri
M = 10.20 days

TABLE 4

Showing date of kidding, date of first mating and interval between parturition and first oestrus of does

HERD NO. OF DOES	DATE OF FIRST MATING	DATE OF KIDDING	INTERVAL BETWEEN PARTURITION AND FIRST MATING
			days
204	18-X-'31	26-XI-'31	39
78	19-X-'31	14-XI-'31	26
96	21-X-'31	18-XI-'31	28
203	21-X-'31	22-XI-'31	32
37	21-X-'31	27-XI-'31	37
173	26-X-'31	21-XI-'31	26
275	19-I-'32	21-X-'32	276
234	23-I-'32	28-II-'32	36
236	24-I-'32	5-VII-'32	194
231	25-I-'32	22-VIII-'32	210
180	27-I-'32	18-V-'32	112
103	27-I-'32	21-II-'32	25
70	27-I-'32	23-X-'32	27
281	31-I-'32	12-X-'32	255
144	1-II-'32	1-III-'32	29
164	23-II-'32	12-VII-'32	139
130	1-III-'32	15-V-'32	75
288	7-III-'32	17-X-'32	224
173	14-IV-'32	8-V-'32	24
96	19-IV-'32	9-VII-'32	81
203	19-IV-'32	22-V-'32	33
314	10-VII-'32 [a]	22-VIII-'32	43
103	20-VII-'32	16-VIII-'32	27
234	22-VII-'32	22-VIII-'32	31
193	27-VII-'32	12-X-'32	77
235	23-IX-'32	12-X-'32	19
203	17-X-'32	5-XII-'32	49
231	9-XI-'32 [a]	27-XI-'32	18
276	11-XI-'32	7-XII-'32	26
78	3-XII-'32	17-I-'33	45
96	4-XII-'32	28-XII-'32	24
173	8-XII-'32	12-I-'33	35
236	2-I-'33	24-IV-'33	112
180	11-I-'33 [a]	21-I-'33	10
234	14-I-'33	13-IV-'33	89
103	15-I-'33	23-I-'33	8
318	10-III-'33	24-VII-'33	136
288	17-III-'33	1-VIII-'33	137
173	8-VI-'33	24-VII-'33	46
180	3-VII-'33	6-VIII-'33	34
96	9-VII-'33	2-VIII-'33	24

M = 91.48 days (range, 8-276 days)

[a] Date doe aborted.

TABLE 5

Showing total milk production from first milking to first oestrus and interval between parturition and first oestrus

HERD NO. OF DOES	PERIOD OF LACTATION	TOTAL MILK PRODUCTION	AVERAGE DAILY MILK PRODUCTION	INTERVAL BETWEEN PARTURITION AND FIRST OESTRUS
	days	*cc.*	*cc.*	*days*
204	33	9,885	299.545	39
78	21	7,915	376.905	26
96	23	12,775	555.435	28
203	27	9,580	354.815	32
173	24	11,510	479.583	26
275	44	3,880	88.182	276
234	32	25,300	790.625	36
236	191	133,320	698.010	194
231	204	121,795	597.034	210
180	108	138,445	1,281.898	112
103	21	12,980	618.095	25
70	23	15,445	671.522	27
281	36	4,310	119.722	255
144	26	16,790	645.769	29
164	3	720	240.000	139
173	18	11,690	649.444	24
96	76	42,875	564.145	81
203	29	14,225	483.534	33
103	22	8,160	370.909	27
234	26	17,870	687.308	31
193	71	66,680	939.155	77
235	13	1,950	150.000	19
203	23	26,575	1,155.435	49
231	19	5,000	263.158	18
276	21	4,275	103.571	26
78	38	11,673	307.184	45
96	17	9,790	575.882	24
173	32	19,980	624.375	35
236	77	49,835	647.208	112
180	8	2,855	356.875	10
234	54	30,825	570.833	89
103	5	1,980	396.000	8
318	117	31,150	266.239	136
288	94	70,535	750.372	137
173	40	18,185	454.625	46
180	26	16,100	619.231	34
96	23	10,250	445.652	24

FLORAL BIOLOGY AND MORPHOLOGY OF THE EGGPLANT[1]

MARIANO V. MAGTANG

WITH FIVE PLATES AND ONE TEXT FIGURE

The development of the flower, gametophytes, fruit and seed of the eggplant is herein described. Some artificial pollination, as well as emasculation and clipping experiments, were undertaken by the writer, and their bearing on the formation of the fruits is also discussed.

Cytological and genetical investigations on the family Solanaceae have been extensive because its species, many of which are of much economic importance, are of wide distribution[2]. The study of the gametophytes on the family is reviewed by Coulter and Chamberlain (1903), Rutgers (1923), Schürhoff (1926) and Schnarf (1929, 1931). Cytological investigations on the development of the female gametophyte was due to Guignard (1882), who worked on the embryo sac development of *Nicotiana tabacum* and *Cestrum splendens*, and concluded that the sac is of the normal type. Soueges (1907), Palm (1922), and Svensson (1926) working respectively with *Atropa belladona*, *Nicotiana "Deli Tabak"*, and *Hyoscyamus niger* respectively, came to the same conclusion as Guignard (1882). Nanetti (1912) and Young (1923) found "Lilium-type" of embryo sac development in *Solanum muricatum* and *S. tuberosum*, respectively. But Banerji in 1931 (Bhaduri, 1932), Cooper (1931) and Bhaduri (1932) found normal type of embryo sac development in *Capsicum annuum*, *Lycopersicum esculentum*, and *Solanum melongena*. It seems that the normal type of embryo sac development is a characteristic of the family Solanaceae[3], and reports of Nanetti and Young should be corroborated before they are accepted.

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[1] Thesis presented for graduation, 1935, with the degree of Bachelor of Science in Agriculture from the College of Agriculture, No. 491; Experiment Station contribution No. 1113. Prepared in the Department of Plant Physiology under the direction of Dr. J. B. Juliano.

[2] Some of the important works on the cytology and the genetics of the family Solanaceae are:

Datura stramonium and hybrids: Belling and Blakeslee (1922, 1923), Blakeslee, Belling and Farnham (1923)
Nicotiana and hybrids: Clausen and Goodspeed (1925)
Capsicum pollen: Kostoff (1926)
Petunia: Fergusson (1927)
Solanum graft hybrids: Winkler (1910, 1916)
Solanum and *Lycopersicum* heteroploid plants: Jϕrgensen (1928)
Solanum pollen meiosis: Kojima (1925)
Solanum, Brunfelsia, Physalis, Cestrum, Withania chromosome numbers: (Bhaduri, 1933)

Schnarf (1931) gives the following morphological characteristics as typical of the family Solanaceae: The anther tapetum forms a multinucleate periplasmodium. The microspore mother cell divides simultaneously, and separation of the daughter nuclei (tetrad) is brought about by furrowing. The mature microspores are binucleate (*Nicotiana tabacum* and *Datura laevis*). In all cases, a single-celled archesporium, which directly functions as a megaspore mother cell, differentiates in the megasporange, and this forms the normal embryo sac. The inner epidermis of the massive integument forms a distinct wall to the sac. Fertilization is porogamous and double fertilization has been demonstrated in some of the plants studied, as, *Hyoscyamus niger, Solanum nigrum, Datura laevis,* and *Nicotiana tabacum.* Cellular (*Atropa belladona, Scopolia carniolica, Physochlaena orientalis, Solanum nigrum, Datura laevis, Nicotiana tabacum. Petunia nyctaginiflora* and *Salpiglossis variabilis*), and nuclear (*Schizanthus pinnatus, Salpiglossis picta,* and *Salpiglossis* sp.) types of endosperm formation are present and intermediate type (helobiale) is known only in *Hyoscyamus niger.*

MATERIAL AND METHODS

Eggplant seeds from a single fruit[4] were obtained in San Carlos, Pangasinan on October 17, 1933. These were germinated at once in sterilized sand in seed boxes. When the seedlings had developed 4 to 5 leaves, they were transplanted in plots in the Experimental Garden of the Department of Plant Physiology, on November 17, 1933. The soil was prepared as usual, but because of its poor condition, a small amount of Ammo-Phos 20-20 fertilizer was applied once to each plant. The second planting was made on June 7, 1934 using the same procedure as with the first. The seeds used in this second planting were secured from the fruits of the first planting.

Flowers, fruits, and seeds in different stages of development were gathered at various intervals from January 10, 1933 to November, 1934. These were fixed and killed in the laboratory with the use of the formalin-acetic-alcohol (70 per cent) prepared according to the formula given by Chamberlain (1932). The material was treated as usual, embedded in paraffin, and sections from 6 to 12 microns thick were cut. Most of these sections were stained in Heidenhain's iron-alum haematoxylin with orange gold dissolved in clove oil as a counterstain. Safranin-light green was used to stain sections of mature seeds.

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[3] The literature in German and French has been translated but not published by Dr. José B. Juliano.

[4] The eggplant used in this study is one of the Native Long.

OBSERVATIONS

The flower

Description. The flowers are borne in small clusters at the axils of the upper leaves. Degeneration often takes place among the other flowers, so that usually in the variety under study only one attains maturity. In some of the eight varieties of eggplants studied (Smith, 1931) in New York rarely more than one flower in an inflorescence is produced, whereas in Oklahoma eggplants produce clustered flowers, 1 per cent of which bear 1-flowered clus-

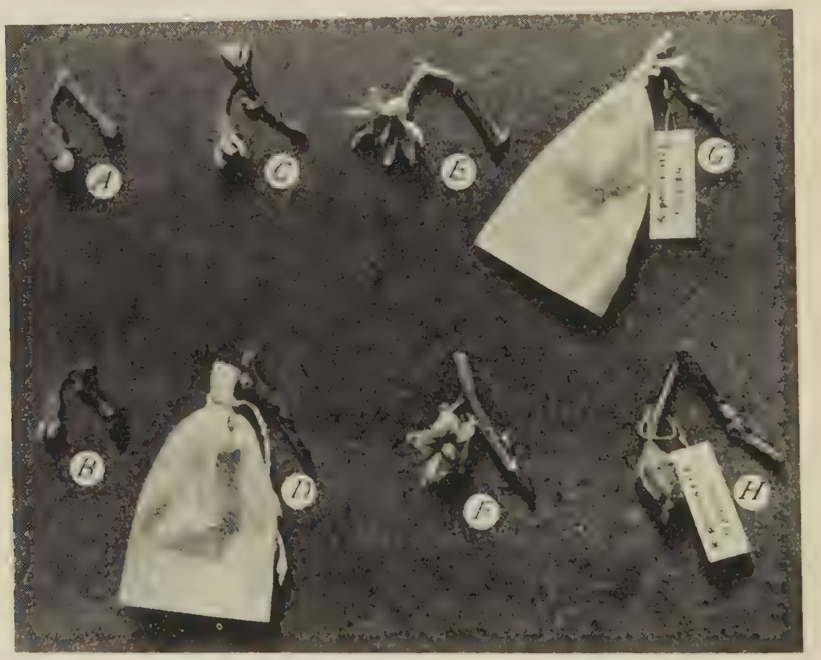

Fig. 1.—Procedure in crossing the eggplant flower. *A*. Flower bud suitable for emasculation; *B*, flower of the same stage after mechanically opening the corolla; *C*. emasculated flower bud; *D*. the same covered with oiled paper bag tied with twine; *E*. emasculated flower at anthesis; *F*. untreated flower at anthesis; *G*. pollinated flower again covered with oiled paper bag secured in position with a piece of twine and marked by tying on a piece of cardboard showing date of pollination; *H*. young fruit six days after pollination.

ter. The functinoal flower is usually bent downward, but a few are held horizontally. Its pedicel is rather long, rounded or terete, violet, and ferruginous-pubescent. Its calyx is 5-parted, forming a distinct cup-shaped structure at its base (pl. 1, fig. 5) ; the lobes are slender, long acuminate, purplish, and covered with ferruginous tomentum. The corolla is rotate campanulate (fig. 1 F), 5-lobed, forming scarcely a tube, pale purplish, but deep purple at veins; lobes unequal, alternating with the calyx lobes, subtriangular and acuminate. The stamens are 5, alternating with corolla lobes, adnate to the corolla; filaments short, flat at base, terete above, white, inserted at one end of the anther; anther yellow, glabrous, 4-lobed (pl. 1, fig .5) dehiscing at the apex, 2-celled (pl. 3, fig. 27), usually turning brownish at dehiscence. The pistil is large; ovary, globular, covered by a few branched trichomes, 4- to 5-celled; placentas large, basal; megasporanges small, numerous, anatropous; style long, often exceeding the anthers in normal flowers, but in those formed early and late it is short, scarcely reaching even half the length of the anthers, covered with hairs to nearly two-thirds, glabrous near the stigma; stigma green, 5-lobed.

Anthesis. On December 28, 1933, exactly forty-one days after planting in the plots, the plants began to set flower buds. The buds appeared as knob-like structures at the axils of the upper leaves. Determinations based on one hundred flower buds showed that those measuring from 2.3 to 2.6 centimeters from the bases of their calyces to the tips of the corollas, usually open the following morning (fig. 1A). These flower buds which open the next morning have their corollas out of their calyx lobes. Twenty-four hours observation based on twenty such flower buds was made on January 20, 1934, and it was found that anthesis lasted from four thirty to five twenty-five in the morning; practically all the flowers were open at seven. It was further noted that not all flowers open during the forenoon; some open in the afternoon; usually opening from twelve thirty to two; by four all are wide open. Kakizaki (1930) made mention of his early work on the biology of the flowers of eggplants in Japan, but unfortunately the writer was not able to have access to Kakizaki's records for comparison with his results.

Dehiscence. Knowledge of the time of dehiscence of the anthers is of particular importance in the hybridization of this plant. To secure this data, on February 3, 1934, five flower buds were carefully observed throughout the night. Bi-hourly examinations of all anthers of the individual flowers were made by gently spreading apart the corolla lobes with a pair of forceps and a hand lens, the light being supplied from a flashlight. It was found that all the anthers of these five flowers had dehisced their microspores by about six o'clock in the morning, February 4, 1934. It was further noted that the anthers of the same flower did not dehisce their microspores at one time, but opening occurred usually one after the other. In other words, dehiscence and anthesis are about synchronous and self-pollination may be possible. In fact, Kakizaki (1930) reports that the flowers of eggplant are self-pollinated to a slight degree. Those flowers which open in the afternoon, usually dehisce their microspores at two twenty-five.

Kakizaki (1930) states that the anthers of eggplant he observed in Japan dehisce their microspores soon after the flowers opened but when the flower is wrapped in a piece of paper, the larger part of the microspores are preserved in the anther and remain capable of functioning for a period of about two days. It seems that the findings of this investigator corroborate those reported by the writer in that anthesis requires about two and half hours during which time the anthers dehisce their microspores.

Clipping off the stigmas. To determine whether pistils of eggplant flowers would mature into fruits if their non-receptive stigmas were clipped off long before anther dehiscence, one hundred and fifty flower buds which were to open the next morning were selected and tagged from time to time from February 5 to July 19, 1934. With a pair of forceps, the corolla lobes were mechanically opened and their stigmas cut off with a small pair of scissors. The treated flower buds opened naturally the morning following the treatment, and were visited from time to time for any possible signs of fruit development.

Results of observation by the writer on the treated flowers showed that all of them dropped off on the third or fourth day. The pistils of flowers that dropped off are dark; the darkening usually begins at the cut end of the style and travels downward into the ovary. Care was exercised to clean the scissors used in cutting off the stigmas so as to prevent any possible contamination by micro-organisms. It seems evident, that an eggplant flower has to be pollinated if it is desired that it produce fruits. It may be possible, however, that clipping off the stigmas is too great a shock to the pistil so that its further development is arrested, if parthenocarpy is a possibility in the eggplant. The writer, however, does not know of any report on parthenocarpy in this vegetable plant.

Emasculation. In order to further prove the validity of the results obtained on the effect of clipping off the stigmas of the flowers on fruit production in eggplant, the writer tried to emasculate, that is, remove the anther before dehiscence (fig. 1 E). Kakizaki's (1930) method of emasculation was followed except that oiled paper bags were used instead of pieces of paper. The present writer believes the bags are better for this purpose. One hundred and fifty flower buds due to open the next morning were used in this experiment. With a pair of forceps, the corolla lobes were opened mechanically and their anthers clipped off (fig. 1, B and C). From time to time several flower buds were treated as stated above from February 5 to July 22, 1934, until the hundred and fifty flowers were emasculated. During the operation, care was exercised not to injure the flowers. After removing the anthers, the treated flower was covered at once with an oiled paper bag (fig. 1 D). On the third day after emasculation, the bag was removed. It was observed that not one of the emasculated flowers formed fruits, falling usually taking place on the third or fourth day.

Kakizaki (1930) reported that the stigmas of the eggplant mature as soon as the flowers open, and, in general, are receptive for a period of two or three days. The stigmas observed by the writer remained green in color for the first and second day after anthesis, but on the third day the color usually changed to dark brown. The results obtained corroborate those from the clipping off the stigmas and clearly demonstrate that pollination is necessary for the formation of fruit in eggplant.

Because emasculated flowers, if left unpollinated, did not form fruits, an attempt to artificially pollinate them was made from February 5 to July 24, 1934. One hundred emasculated flowers were artificially cross-pollinated with microspores from flowers (fig. 1 F) of different plants growing in the Experimental Garden of the Department of Plant Physiology. After pollinating a flower, it was then covered for three days (fig. 1 G) with the same oiled paper bag. Only 81 such flowers ever produced fruits (fig. 1 H). Bayla (1918), as well as Kakizaki (1930), were able to cross-pollinate several varieties of eggplants, the latter obtaining as high as 80 to 90 per cent success in his crosses. Bayla tried to make reciprocal crossings between Native Long and New York Improved, and obtained vigorous and productive individuals in F_1 generation. It is evident that emasculation alone does not inhibit fruit formation, and if pollinated, fruit formation follows. The present work confirms the conclusions arrived at by Bayla that pollination is necessary in fruit formation.

The failure of other flowers to form fruit could be ascribed perhaps to incidental injuries inflicted during the emasculation operation, although great care was taken to prevent such injuries.

Kakizaki (1930) mentions that natural crossings sometimes occur to an appreciable extent in eggplant flowers, otherwise it is ordinarily self-fertile. In order to determine whether self-pollination can take place without the intervention of outside factors, normal flowers were covered with oiled paper bags late in the afternoon (6:00 p.m.), and these covers were removed two days after anthesis. Of the hundred flowers thus treated, not one developed fruit. The flowers dropped off usually on the fourth day after bagging; in some instances they were observed to drop off as early as the third day. Results of this bagging experiment seem to indicate that self-pollination, or autogamy, is not possible under local conditions. Furthermore, fruit may not develop if the pistils produce short styles, so that their stigmas will not be borne at the same level or even beyond the pores of the anthers. This condition is pronounced among both early and late formed flowers. In fact, Smith (1931) found that of the total (221) eggplant flowers which developed from plants grown in New York, 98.2 per cent had poorly developed styles and only 1.8 per cent showed normal length of styles. Practically all the flowers that dropped were borne in many-flowered inflorescence and had very small pedicels. The same author found that the diameter of the pedicel is directly correlated with the length of the style and that relation between small size of pedicel, small phloem area in the pedicel and weak expression of femaleness in flowers borne on this pedicel are direct. Histological examination of short-styled and normal-styled flowers at anthesis failed to show any marked parallelism between stuntedness of styles and the degree of degeneration of the megasporanges and the embryo sac.

Artificially self-pollinating the flowers was tried also by the writer. On July 28, 1934 ten flower buds were selected and covered with oiled paper bags the afternoon previous to anthesis. When these flowers opened the next morning, the covers were removed, and the stigmas were dusted with microspores from their own anthers, care being taken to clean the forceps after working on each flower. After artificially self-pollinating a flower, it was again covered with the same oiled paper bag, which was not removed until after three days. All the selfed flowers formed fruits, thus confirming the conclusion arrived at by Kakizaki (1930) that eggplant flower is ordinarily self-fertile.

Insect visitors. Throughout the flowering period of the eggplants under observation, several insect visitors were noted. These were usually abundant from seven to ten in the morning, and only casual visits were made during the rest of the day. On two bright sunny days (August 24, and September 2, 1934), the writer collected several insect visitors from six o'clock in the morning to six o'clock in the evening. The most common bees were *Apis indica* Fabricus race *nigrocincta* Smith (Apidae)[5], *Nomia quadrifasciata* Ashmead (Andrenidae), *Xylocopa fuliginata* Pérez (Xylocopidae), *Mesotrichia philippinensis* Smith var. *chlorina* Cockerell (Xylocopidae), and *Anthophora korotonensis* Cockerell (Anthophoridae). These insects visit one flower after another and thus render cross-pollination possible. Besides, several species of ants were often found crawling on the plants.

Organography. The flowers of eggplant are borne in clusters at the axil of the leaves of which only one flower attained maturity in the variety under study. In other varieties more than one flower in a cluster may attain maturity (Smith, 1931). The floral primordium emerges as a conical protrusion in the axil of a bract on the floral cluster. The first floral organ to emerge on the floral primordium are the sepals (pl. 1, fig. 1) which differentiate as small papillae in a single whorl; these elongate very early upward, and then bend inward, thus giving a protection to the growing point of the young flower. When the sepals have formed a cover on the young growing point, the petals (pl. 1, fig. 2) arise as small outgrowths in a single whorl, within the calyx lobes. As the petals grow and elongate, they push the sepals apart (pl. 1, fig. 3-4), thus the corolla lobes become the permanent cover to the flower until after anthesis. The next floral organ to differentiate are the stamens (pl. 1, fig. 3), which arise as five tubular projections within the whorl of the petals. These are at first free from the petals but later become fused at the base of the gamopetalous corolla. The last organ to be formed on the floral primordium are the five carpels (pl. 1, fig. 3-4). In other words, the floral organs of the eggplant arise as follows: sepals, petals, stamens and carpels. It is, therefore, acropetal as is true of those described for related plants (Young, 1923).

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[5] The identification of these insects was made by Dr. Leopoldo B. Uichanco, of the Department of Entomology, for which the writer expresses thanks.

MEGASPORANGE AND MEGAGAMETOPHYTE

Megasporange. The placentas are rather extensive outgrowths from the basal portion of the ovary (pl. 1, fig. 5), possessing a distinct epidermal layer which is rather uniform, and presents an even surface. Enclosed by this epidermis is a homogeneous hypodermal tissue; cells are isodiametric, meristematic and possess thick cytoplasm and rather large, well-stained nuclei. The placentas fill up the locule; these spread out laterally (pl. 3, fig. 32). At the initiation of the development of the megasporanges three to four or even more hypodermal cells of the placenta, together with the subtending epidermal cells, become differentiated from the rest of the placental tissue. These cells contain dense cytoplasm and conspicuous nuclei almost filling their cavities. At first, these hypodermal cells divide in one direction, while the subtending epidermal cells divide anticlinally so as to keep pace with the enlarging hypodermal cells of the young megasporange. Placental cells lying between adjacent initials of megasporanges remain inactive, and later become compressed and distorted. At this time the placentas lose their evenness, and become wavy in outline (pl. 1, fig. 5; pl. 3, fig. 32). The individual megasporange initial is now easily discernible as a small papilla on the placenta.

Growth of these young papillae (megasporanges) proceeds by cell division, but their growth is much more on one side than on the other, consequently, these megasporanges are then bent laterally in various directions. The nucellar tissue is very much differentiated and the funiculus remains inconspicuous. It is at this time that the archesporium is differentiated (pl. 1, fig. 6).

The integument, which is only one in the family Solanaceae, differentiates after the appearance of the archesporium. It is epidermal in origin (pl. 1, fig. 7). A single epidermal cell behind the archesporium divides periclinally. This division is followed by the hypodermal cells and consequently notches appear as the forerunner of the single integument. This integument grows very rapidly so that it forms an extensive cover to the scanty nucellus of the individual megasporange as the latter develops, and on which the sac later abuts (pl. 2, fig. 15).

Megaspore mother cell. The archesporial cell differentiates long before the primordium of the megasporange has begun to show unequal growth (pl. 1, fig. 6), and before the initiation of the single integument. This archesporial cell is a large, wedge-shaped cell containing a conspicuously large nucleus and dense cytoplasm. While one archesporial cell is the rule in the material examined by the writer, the occurrence of two archesporial cells (pl. 1, fig. 8) is not wanting. These usually lie side by side, and are apparently equal in size and shape. Bhaduri (1932) reports the same behavior in eggplants he examined in India. He also noted the differentiation of three archesporial cells in a linear direction. Not infrequently, however, the same author observes that some of the innermost integumental cells become differentiated from the rest, and in one case a nucellar chalazal cell back of the embryo sac developed into four linear megaspores. None of these features were noted by the writer in the material he has examined.

The formation of multicellular archesporium is not confined only to *Solanum melongena* in the family Solanaceae. In *Solanum tuberosum*, Young (1923) reported the occurrence of two to three archesproial cells in the same nucellus of a megasporange.

The archesporial cell in this species functions as the megaspore mother cell direct, thus confirming the findings of Bhaduri (1932). Identical behavior of the archesporial cell has been reported in *Solanum tuberosum* (Young, 1923), *S. nigrum* × *luteum* (Jφrgensen, 1928) and *Lycopersicum esculentum* (Cooper, 1931).

The megaspore mother cell then enlarges and elongates with its enlarged portion directed towards the micropyle (pl. 1, fig. 7). During the growth of the megaspore mother cell, the scanty nucellar tissue becomes destroyed, and the cell finally lies against the nucellar epidermis. Soon, its nucleus enters synapsis (pl. 1, fig. 9). By two successive divisions of this megaspore mother cell, it gives rise to normal linear tetrads of four megaspores (pl. 1, fig. 11). The writer was not so fortunate as to find mitotic figures in the divisions of the megaspore mother cell, except that represented in plate 1, figure 10. Here, the chromosomes are not easily discernible, and clumping is evident, thus preventing the counting of its chromosomes.

The daughter megaspores, or tetrads, are at first alike in size and shape, each possessing a conspicuous nucleus and large, deeply stained nucleoli. The resting stage is very short, and differentiation sets in immediately. Generally, the chalazal megaspore becomes functional (pl. 1, fig. 13) and gives rise to the embryo sac, while the three micropylar megaspores degenerate and form a cap over it as groups of deeply stained masses. Sometimes, however, the micropylar megaspores may exhibit active growth and early enlargement (pl. 1, fig. 11), and in other cases the chalazal, as well as the second from the micropylar end, are observed to develop simultaneously (pl. 1, fig. 12). Bhaduri (1932) finds that the third megaspore from the micropylar end develops simultaneously side by side with the chalazal megaspore. But, even if these abnormal enlargements of megaspores other than chalazal take place, the innermost megaspore always becomes functional.

Embryo sac. The functional megaspore enlarges and by three successive divisions of its nucleus, it forms the normal seven-celled megagametophyte. After the first division of the nucleus, the two daughter nuclei usually lie side by side near the micropylar end of the sac, at which time the whole nucellar tissue has disappeared completely and the sac abuts against the massive integument (pl. 1, fig. 14). The inner epidermis of the single integument undergoes differentiation, and forms the "tapetum" covering the sac. These cells radially elongate, while others enlarge considerably, their nuclei becoming large and cytoplasm thick and dense. Bhaduri (1932) observes several stages of karyokenetic divisions among these inner epidermal cells (tapetum), but their nuclei never develop into separate cells. Vacuolation of the sac is evident, and the cytoplasm is thickest at the micropylar end. Later, the two daughter nuclei migrate to the poles (pl. 2, fig. 16), where they divide again to form the four nuclei (pl. 2, fig. 17).

The mature sac contains an egg apparatus (an egg and two synergids), two polar nuclei, and three antipodals. The findings of Bhaduri (1932) are here confirmed by those of the writer. The synergids are pear-shaped, each with a long acute beak. Their nuclei are situated near the center just below their terminal vacuole (pl. 2, fig. 18). These synergids possess no filiform apparatus. The egg, or megagamete, is much smaller than either of the two synergids and lie behind and between them. It possesses a dense cytoplasm in which is embedded a conspicuous nucleus. The polar nuclei usually lie near each other at the vicinity of the egg apparatus. These synergids are oblong and much larger than any of the cells of the egg apparatus. The writer was not so fortunate as to observe the presence of the antipodals in all the slides he examined, but Bhaduri (1932) describes them as lens-shaped cells lying close together and filling the chalazal groove of the sac. These antipodals are ephemeral and disappear long before fertilization. This fact is responsible, perhaps, for their absence in the material examined by the writer.

Early workers found that the "normal type" of the embryo sac development is a characteristic of the family Solanaceae, but Nanetti (1912) and Young (1923) found "Lilium-type" of development in *Solanum muricatum* and *S. tuberosum.* In *S. melongena* as well as *S. nigrum,* Bhaduri (1932) observed "normal type" of development of the female gametophyte, and the present work confirmed this finding in the first species. It is probable that "normal type" of development of the female gametophyte is a common feature in the genus *Solanum,* and that the results of Nanetti and of Young require corroboration before they be accepted. In fact, in the family Solanaceae the "normal type" of embryo sac formation is a general characteristic (Schnarf, 1931).

The development of more than one embryo sac in a megasporange was not observed by the writer in the eggplant material on which he worked. Bhaduri (1932) states that the development of two embryo sacs in the bi- or quadri-nucleate stage is also an abnormal feature he observed in *Solanum melongena* material he examined. Young (1922) found two embryo sacs in the same megasporange in *Solanum tuberosum,* which is believed by him to be a case of proliferation or doubling, analogous to the hypertrophied conditions known as fasciation sometimes observed in stems and other organs. Bhaduri (1932) expresses the belief that in eggplant, formation of two sacs in the same megasporange is due to initiation of other megaspores, besides the normal functional one.

MICROSPORANGE AND MICROSPORE

The stamens very early form their short filaments and enlarged club-shaped anthers (pl. 1, fig. 3-4). The young anthers are rounded in transverse section, later becoming 4-lobed, surrounded by a distinct epidermis within which is a mass of meristematic and isodiametric cells containing dense cytoplasm and distinctly large nuclei. The archesporium differentiates as a row of cells at the third layer below of the epidermis of the anther (pl. 2, fig. 19). These cells are easily discernible from their surrounding cells in that they have dense cytoplasm, large nuclei and nucleoli which take the stains deeply. The two layers of parietal cells, external to the archesporial tissue, becomes thick (pl. 2, fig. 20-21) by repeated periclinal divisions, the innermost layer of which functions as the tapetum.

The archesporial cells, by repeated divisions, form a mass of microspore mother cells (pl. 2, fig. 20-21), which assume the form of an arch across the microsporange and extend throughout the length of the anther. The writer was not so fortunate as to have an abundance of material on which to trace meiosis of the mother cells in detail. Kojima (1925) traced this in two races of eggplant in Japan and counted the chromosomes of 21 different races of the same species as 12. By two simultaneous divisions of the microspore mother cell, a normal tetrad (pl. 2, fig. 25) is formed. The daughter microspores are at first inclosed by a somewhat mucilaginous coat, derived, perhaps, from the wall of the mother cell, which upon dissolution liberates the microspore. These microspores upon being liberated round off and acquire their own coats (pl. 2, fig. 26). They are uninucleate long before dehiscence, and whether they become bi- or tri-nucleate at dehiscence, the writer was not able to determine. Simultaneous division of the pollen mother cells was observed in *Solanum tuberosum* (Young, 1923), *Nolana* (Campin, 1925), *Solandra grandiflora* (Campin, 1924), *Nicotiana* (Farr, 1916), and *Datura* (Yamaha, 1926).

The tapetal cells are at first uninucleate (pl. 2, fig. 20-21), and are easily differentiated from the microspore mother cell as well as the rest of the parietal tissue by their dense cytoplasm and large nuclei. By the time the microspore mother cells are in synapsis, the tapetal cell nuclei undergo division (pl. 2, fig. 22-23) so that by the time the tetrad stage is reached, the tapetal cells are already bi-nucleate (pl. 2, fig. 24). These tapetal cells persist during meiosis, but are later absorbed and degenerate.

In *Datura arborea* L., Mascré (1919a) found that its tapetal cells are remarkably rich in cytoplasm and these actually undergo division at the synaptic stage of the microspore mother cells; at the tetrad stage the tapetal cells are bi- to quadri-nucleate. By the time the microspores have differentiated well their exines, the tapetal cells are well modified; their cellular membranes are slightly suberized. The parietal tissue then disappears, their cells dissociate, somewhat, and their nuclei disappear. The poor nuclei probably fuse freely, two by two, and these fused nuclei present an aspect of a particular amoeba. The same author (Mascré, 1919b) observed the same thing in *D. stramonium* L. and *D. tatula* L. In *D. dulcamara* L., the tapetal cells are well developed, vacuolated and binucleate long before the external parietal cells have reached their mature stage.

Smith (1933) cites that Duggar in 1910, Tischler in 1906, Winkler and Tahara in 1910, found mitotic divisions of the tapetal cells in *Bignonia venusta*, *Ribes*, *Wikstroema indica*, and *Morus alba*, respectively. Cooper (1933) also added 21 species of flowering plants as exhibiting mitotic divisions of the nuclei of their tapetal cells. *Lycopersicum esculentum* (Cooper, 1931) and *Mangifera indica* (Juliano and Cuevas, 1932) also show division of the nuclei of their tapetal cells. Juliano and Alcala (1933), working on *Musa errans* var. *botoan*, found binucleate tapetal cells.

The rest of the parietal tissue likewise undergoes complete degeneration during the development of the microspore. The tissue between the two adjacent microsporanges, which remains intact for a long while, becomes destroyed so that these two sporanges merge together forming a large locule (pl. 3, fig. 27). Thus, the mature anther becomes bi-locular. Because the anthers have terminal pores, the anther wall remains intact, and the development of normal rod-shaped thickenings in the endothecial cells is found wanting.

FRUIT

Description. The fruit (pl. 3, fig. 34) is a fleshy, oblong berry, green when young, turning purplish at maturity. When over-ripe, the fruit turns yellowish. It is enlarged at its terminal portion and slightly tapers towards the base. The persistent calyx is tough and green, at the base of which the pedicel is attached. The fruit usually measures from 21 to 23 centimeters in length at maturity. Inside the fruit are found numerous small seeds.

Development. Soon after the fertilization, the corolla fades and falls off, and the ovary then enlarges. The stigma darkens, and this darkening proceeds down to the style. Later, the style and pistil abscind from the ovary. The ovary then elongates and enlarges simultaneously, greenish when young, and acquiring its violet purple color as it approaches maturity.

The ovary wall before fertilization consists of homogeneous, meristematic, isodiametric, thin-walled cells, delimited on two sides by distinct epidermal layers of rectangular to squarish cells (pl. 3, fig. 28). Traversing the ovary wall are distinct vascular bundles. Differentiation takes place some time before the ovary has attained a diameter of 11 millimeters (pl. 3, fig. 29). The hypodermal layers of cells, ranging from 5 to 7 in number, remain small, with their long axes parallel to the length of the fruit; these cell layers form the exocarp. In the epidermal cells of the exocarp, the purplish color of the fruit believed to be delphinidin chloride (Kuroda and Wada, 1933), is found. The exocarp is sometimes spoken of as the "skin" of the mature fruit, and this separates easily after boiling.

The hypodermal cells, or endocarp, which form the bulk of the pericarp, greatly enlarge (pl. 3, fig. 30) and air spaces are developed between them. Those cells toward the inner epidermis of the pericarp are much smaller (pl. 3, fig. 31) than those at the middle of the pericarp. This inner portion of the pericarp becomes fleshy and together with the walls between the loculi, as well as the placentas, form the edible portion of the fruit. In several instances the seeds are eaten with this edible portion of the fruit.

SEED

Description. The seed is pale yellow, small, reniform (pl. 3, fig. 33), and flattened on two sides (pl. 3, fig. 35). It possesses a well-developed testa, or coat, the surface of which is somewhat rugose. Within the coat are the endosperm and the coiled embryo consisting of a pair of cotyledons, a short plumule, and a stubby radicle (pl. 5, fig. 52), which is situated near the micropyle (orthotropous or homotropous).

Seed coat. The seed coat is rather thin, hard, with an average thickness of from 0.12 to 0.15 millimeter. It is rather yellowish white and consists of two distinct layers of lignified cells covered on the outside with a heavy coat of cutin (pl. 4, fig. 42).

The young integument to the megasporange at the time the megaspore mother cell is in synapsis, consists of two to four layers of meristematic isodiametric cells (pl. 4, fig. 36) and hardly covers the summit of the nucellus. As it grows downward, it increases in thickness, by active anticlinal and periclinal divisions of its cells; the most conspicuous growth, however, is exhibited by both epidermal layers. The outer epidermal cells enlarge very greatly (pl. 4, fig. 37), while the cells of the inner epidermis, especially those abutting the embryo sac, become conspicuously rich in cytoplasm, taking the stains very deeply (pl. 5, fig. 51). These inner epidermal cells in early stages of growth show greater diameter than those of the hypodermal cells (pl. 4, fig. 37), but due to the growth of the sac, these ultimately become compressed, reduced in size, and often flattened tangentially (pl. 5, fig. 51).

The first sign of differentiation of the integumental cells, as has been stated above, is the enlargement of the outer epidermal cells as well as those of the inner epidermal cells which function as the "tapetum". As growth of the seed continues, a differential rate of enlargement among the cells of the outer epidermis takes place (pl. 4, fig. 37-38). Some of the cells enlarge much more rapidly than the others, which become compressed and often undergo degeneration, as shown by the dissolution of their radial walls (pl. 4, fig. 38). In surface view these epidermal cells possess wavy radial walls (pl. 4, fig. 39), which become thickened and lignified later (pl. 4, fig. 41); their tangential outer walls eventually become coated with a rather thick cutinized layer (pl. 4, fig. 38, 40, 42). Simultaneously with this differential enlargement of the outer epidermal cells of the integument, the hypodermal cells become tangentially compressed, because of the growth of the sac within, and begin to show early degeneration (pl. 4, fig. 38).

Lignification of the outer epidermal cells then takes place long before the maturity of the seed (pl. 4, fig. 40). Deposition of lignified material takes place on the walls of the remaining epidermal cells, and includes those remains of dead cells, so that, in transverse section, the radial walls separating the enlarged epidermal cells are often variously pitted, the pits being either in the form of rounded or elongated slits (pl. 4, fig. 40). On the inner and outer tangential sides of the enlarged cells can be found the lignified remains of walls of the destroyed, degenerate sister cells as small pegs protruding inward.

The hypodermal cells lying between the inner and outer epidermal layers are totally compressed and eventually degenerate, so that at maturity of the seed, nothing remains except their compressed walls (pl. 4, fig. 42). The inner epidermal cells, however, continue to persist as a distinct coat to the endosperm, and these can be easily differentiated from the latter by being small, tangentially flattened, the walls of which are much thicker than the endosperm cells, especially at the time the seed is half mature.

At maturity of the seed nothing remains of the massive integument except the outer and inner epidermal layers (pl. 4, fig. 42). The outer epidermal cells are variously shaped and highly lignified, many of which entirely lose their lumina. The lignified walls show definite striations, but lack the characteristic radial canals found in normal stone cells. The inner epidermal cells, however, are much smaller in size than those from the outer epidermis, and are also lignified. These are more or less rectangular with their long axes either periclinally or anticlinally directed. Lying between the two distinct layers of lignified cells are wall remains of the hypodermal cells. Covering the seed coat on the outside is a heavy and thick cutinized layer. The seed coat is thickest at the ridges of the seed, and its continuity is only broken at the micropylar portion of the mature seed (pl. 5, fig. 52). In other words, the tissues which take active part in the formation of the mature seed coat are the inner and outer epidermal cells of the massive integument.

Endosperm. The endosperm of eggplant is of the cellular type, a character that has been found in many members of the family Solanaceae.

Fertilization in eggplant is porogamous (pl. 4, fig. 43), and the pollen tube enters the megasporange through its micropyle, although no actual discharge of the contents of the pollen tube was seen by the writer. The tube enters the embryo sac between the two synergids which soon degenerate. After fertilization the primary endosperm nucleus is more or less spherical and possesses two distinct nucleoli and dense nucleoplasm; this lies just adjacent to the zygote. Division of the primary endosperm nucleus is successive and transverse (pl. 5, fig. 49) but later divisions were not followed by the writer in detail. However, the whole embryo sac becomes wholly filled with cellular endosperm (pl. 5, fig. 50).

A distinctive feature observed in the development of the endosperm of this particular plant is the formation of large, conspicuous, more or less tapering cells at the chalazal end of the sac (pl. 5, fig. 50-51). These cells contain dense cytoplasm wherein are embedded their distinct, large, deeply stained nuclei. By their position and shape, they are regarded by the writer as "haustorial cells", a character not yet reported, apparently, in many members of the family Solanaceae. At a later stage in the development of the seed, these "haustorial cells" finally disappear, hence are only ephemeral in nature.

The mature endosperm is surrounded by distinct peripheral cells which are either radially elongated or isodiametric in transverse section and is herein designated as the aleurone layer. Lying enclosed by this distinct single-layered aleurone are more or less isodiametric, thick-walled cells which constitute the mass of the endosperm. In these cells, as well as in the aleurone, are found numerous starch grains. Distinct middle lamellae can be seen between the individual cells of the endosperm (pl. 4, fig. 42).

Endosperm formation *Atropa belladona* (Hegelmaier, 1886), *Scopolia carniolica, Physochlaena orientalis,* and *Solanum nigrum* is brought about by successive divisions of the primary endosperm cell (Schürhoff, 1926). Other species which exhibit cellular type of endosperm are *Datura laevis, Nicotiana tabacum, Petunia nyctaginiflora* and *Salpiglossis variabilis* (Schnarf, 1929). Although this type of endosperm is very common among representatives of the family Solanaceae, other members, however, exhibit other types. For example, Hofmeister (1858) found nuclear type of endosperm in *Salpiglossis picta* and *Salpiglossis* sp.; *Schizanthus pinnatus* was observed by Samuelsson in 1913 (Schnarf, 1929) to exhibit identical type of endosperm. An extreme deviation from the common type (cellular) of endosperm was found in *Hyoscyamus niger* by Svensson in 1925 and 1926 (Schnarf, 1929) where it is of the helobiale type.

Embryo. The coiled embryo of the eggplant is rather large and consists of two cotyledons, a short plumule, and a stubby radicle, embedded in an endosperm (pl. 5, fig. 52). These are covered on the outside by the lignified hard seed coat.

The zygote does not divide soon after fertilization (pl. 4, fig. 43). The first divisions of the zygote are transverse (pl. 4, fig. 44-45). The writer believes that the development of the embryo in *Solanum melongena* is perhaps similar, if not identical, to that reported for *Nicotiana tabacum* (Souèges, 1920), although the material on hand is not sufficient to warrant a very definite statement. The three-celled zygote (pl. 4, fig. 44) shows a small rounded basal cell, a larger intermediate and an apical large cell. By a series of transverse walls this zygote forms a long suspensor, its apical, elongated large cell forming the proembryo (pl. 4, fig. 45). By the time an octant is formed (pl. 5, fig. 46) the lower cell divides vertically into two. The upper tier forms the epicotyl and the cotyledon; the second tier, the hypocotyl, and the third tier, the hypocotyledonary cap. A distinct dermatogen is formed (pl. 5, fig. 47) to the proembryo, and later, a massive globular juvenile embryo is developed (pl. 5, fig. 48), possessing a distinct long suspensor. Further development was not followed for lack of sufficient material.

Nucellus. In the megasporange the nucellus is comparatively large (pl. 1, fig. 6-8), but during the subsequent enlargement of the megaspore mother cell (pl. 1, fig. 9), the nucellar cells, except its epidermis, are totally absorbed, the latter disappearing only at the binucleate stage of the sac (pl. 1, fig. 14). Hence, at maturity of the seed not a trace of the nucellar tissue is evident.

SUMMARY AND CONCLUSIONS

The development of the flower, gametophytes, fruit and seed of *Solanum melongena* Linn. (one of the Native Long varieties) are herein described.

The floral organs develop as follows: sepals, petals, stamens and carpels.

The flowers usually open between four thirty and five twenty-five in the morning; practically all are open by seven. Some, however, open in the afternoon from twelve thirty to two and are wide open at four. Anther dehiscence takes place during anthesis, and hence, they are nearly synchronous.

Clipping experiments, as well as emasculation, proved that pollination is necessary in fruit formation. This plant is self-, close- and cross-fertile. The failure of several flowers to develop fruits is ascribed to the development of abnormal style, and hence the lack of expression of femaleness. Several insect visitors were noted. These make pollination among the flowers comparatively easy.

The megasporange, or ovule, initial differentiates as groups of embryonic cells from subepidermal layers of the massive placenta. The single integument develops after the formation of the archesporium and this covers the embryo sac when fully mature. The one-celled archesporium (two-celled is not uncommon) functions direct as a megaspore mother cell, which gives rise to a normal linear tetrad, the innermost of which forms the normal seven-celled embryo sac.

The archesporium from the microsporange differentiates from the third layer of hypodermal cells, which by successive divisions form a mass of microspore mother cells, dividing simultaneously. The parietal tissue becomes 6-layered, the innermost layer of which functions as the tapetum, while the outer layers degenerate and never form any endothecial layer so prominent in anthers of other plants. The normal tetrads which become separated by furrowing, are at first uninucleate long before dehiscence.

Fertilization is porogamous, and the synergids are destroyed by the pollen tube.

The pericarp forms the exocarp or "skin", and the inner fleshy edible portion, the endocarp. This endocarp together with the placentas and the walls separating the loculi (even the seeds) contribute *in toto* to the formation of the edible portion of the berry.

The endosperm is of the cellular type, and this exhibits a group of chalazal, greatly differentiated, ephemeral "haustorial cells". Development of the zygote is perhaps normal.

The mature seed coat comes from the inner and outer epidermal cells of the massive integument which become greatly lignified.

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EXPLANATION OF PLATES

Parts of the flower, fruit and seed are designated as follows: epicotyl and cotyledon (*a*), aleurone layer (*al*), archesporium (*ar*), carpel or pistil (*c*), calyx (*ca*), cutinized layer (*cl*), cotyledon (*ct*), dermatogen (*d*), embryo(*em*), endosperm (*en*), epidermis (*ep*), embryo sac (*es*), exocarp (*ex*), haustorial cell (*hc*), hypocotyl (*hy*), hypocotyledonary cap (*hyc*), integument (*i*), inner epidermis (*iep*), locule (*l*), micropyle (*mc*), megagamete or egg (*me*), microspore mother cell (*mimc*), outer epidermis (*oep*), petal (*p*), parietal tissue (*pat*), pedicel (*pe*) pro-embryo (*pem*), primary endosperm nucleus (*pen*), plumule (*plu*), plar nuclei (*pn*), pollen tube (*pt*), radicle (*r*), sepal (*s*), seed coat (*sc*), stamen (*st*), suspensor (*sus*), synergid (*sy*), tapetum (*t*), vascular bundle (*vb*), and zygote (*zy*).

PLATE 1

Fig. 1. Longitudinal section of a floral primordium showing the beginning of the sepals. × 43.

Fig. 2. Young floral primordium showing the sepals and petals already differentiated. × 43.

Fig. 3. Showing the stamens and carpels already well developed. × 18.

Fig. 4. An older floral bud showing all its parts fully formed. × 18.

Fig. 5. Diagram of a transverse section of a young flower showing the relative positions of all its parts. × 18.

Fig. 6. A young megasporange showing a single hypodermal archesporial cell. × 450.

Fig. 7. An older megasporange; note the beginning of the integument. × 890.

Fig. 8. Showing differentiation of two archesporial cells in the nucellus of a young megasporange. × 890.

Fig. 9. Enlarged megaspore mother cell in synapsis. Note the absence of nucellar cells except the epidermis. × 1060.

Fig. 10. Megaspore mother cell at anaphase stage of the heterotypic division. × 1060.

Fig. 11. Tetrads. × 1060.

Fig. 12. Tetrads; chalazal as well as the second megaspore from the micropylar end showing activity. × 1060.

Fig. 13. Tetrads; chalazal megaspore functional. × 1060.

Fig. 14. Binucleate megagametophyte; sac has completely destroyed the nucellus and comes to lie against the inner epidermis of the integument forming the "tapetum". × 890.

PLATE 2

Fig. 15. A diagram of a longitudinal section of a megasporange showing the massive integument and the binucleate sac. × 54.

Fig. 16. Binucleate sac showing distinct polarity; taken from fig. 15. × 1060.

Fig. 17. Quadri-nucleate embryo sac. × 890.

Fig. 18. Mature embryo sac showing the egg apparatus, and the polar nuclei. × 1060.

Fig. 19. Portion of a transverse section of a microsporange showing the archesporium and two-layered parietal tissue. × 1060.

Fig. 20. An older microsporange showing the sporogenous tissue and the young tapetum. × 1060.

Fig. 21. A still older microsporange showing the microspore mother cells and the parietal tissue. × 540.

Fig. 22. A tapetal cell with its nucleus at metaphase stage. × 1060.

Fig. 23. Another tapetal cell with its nucleus at telephase stage. × 1060.

Fig. 24. Binucleate tapetal cell. × 1060.

Fig. 25. Tetrad (a diagrammatic sketch). Note the "mucilage" coat derived from the mother cell. × 1060.

Fig. 26. A single microspore long before dehiscence. × 1060.

PLATE 3

Fig. 27. Diagram of a transverse section of an anther before dehiscence. × 18.

Fig. 28. Portion of a transverse section of the ovary wall of a mature flower. × 1060.

Fig. 29. Portion of a transverse section of the pericarp of nearly mature fruit showing the exocarp. × 235.

Fig. 30. Showing the middle portion of the endocarp and including a vascular bundle. × 235.

Fig. 31. Showing the inner portion of the endocarp. × 490.

Fig. 32. Diagram of a transverse section of a very young fruit showing the arrangement of the young seeds. × 18.

Fig. 33. Side view of a mature seed. × 5.

Fig. 34. Lateral view of a mature fruit. × 0.3.

Fig. 35. Frontal view of a mature seed showing the micropyle. × 5.

PLATE 4

Fig. 36. Showing integument of a young megasporange with megaspore mother cell in synapsis. × 890.

Fig. 37. Portion of a transverse section of the seed coat some time after fertilization. × 540.

Fig. 38. Portion of a seed coat showing differential enlargement of the outer epidermal cells. × 235.

Fig. 39. Surface view of the epidermal cell (same stage as fig. 38). × 112.

Fig. 40. Epidermal cells of the integument undergoing lignification. × 235.

Fig. 41. Surface view of mature seed coat (outer epidermis of the integument). × 235.

Fig. 42. Transverse section of mature seed coat; note endosperm cells with aleurone layer. × 235.

Fig. 43. Portion of an embryo sac after fertilization showing pollen tube, zygote and primary endosperm nucleus. × 1060.

Fig. 44. Three-celled zygote. × 1060.

Fig. 45. Five-celled zygote, terminal cell is pro-embryo, while lower cells form the suspensor. × 1060.

PLATE 5

Fig. 46. Eight-celled proembryo with long suspensor. × 1060.

Fig. 47. Proembryo showing the dermatogen. × 1060.

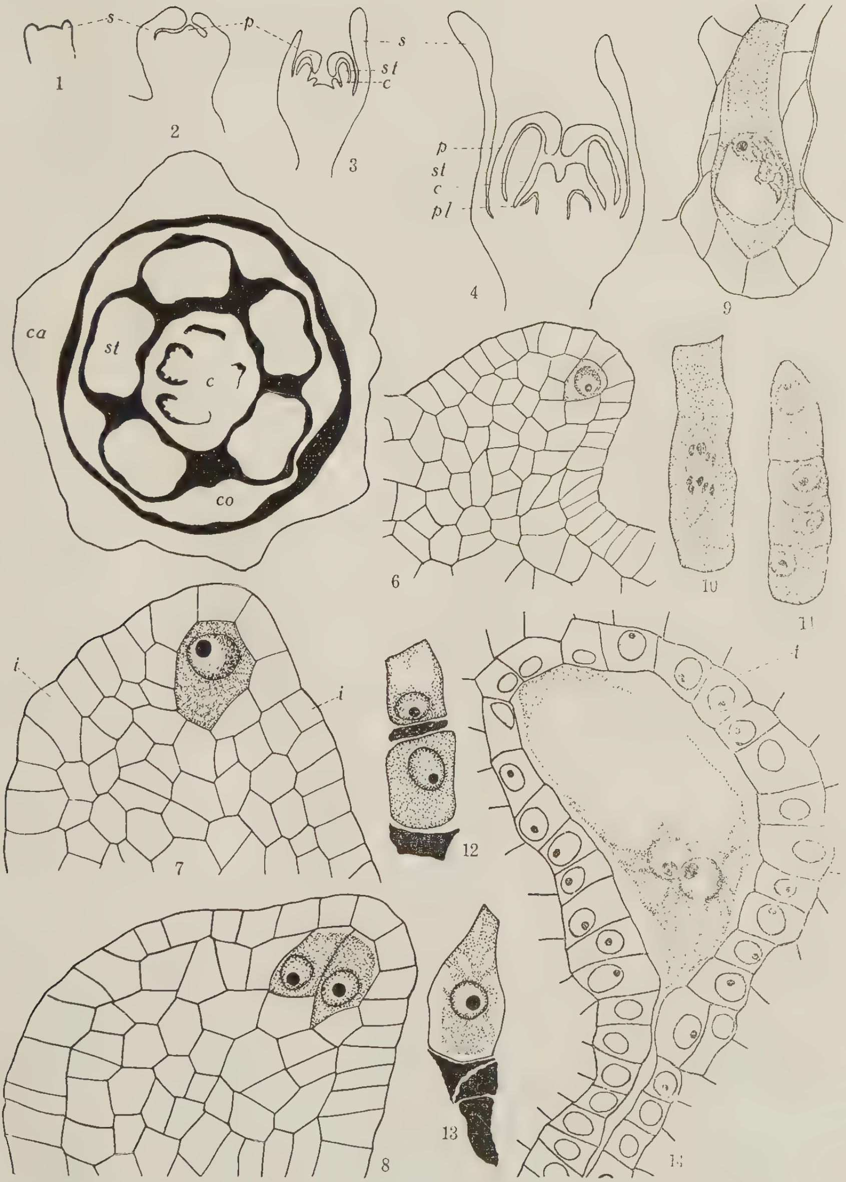
Fig. 48. An older proembryo. × 1060.

Fig. 49. Embryo sac showing early development of cellular endosperm. × 540.

Fig. 50. Embryo sac showing cellular endosperm and embryo; note the development of large basal "haustorial cells". × 99.

Fig. 51. "Haustorial cells" of the endosperm. × 490.

Fig. 52. Diagram of the longitudinal section of the seed cut parallel to its flat surface showing positions of its parts. × 7.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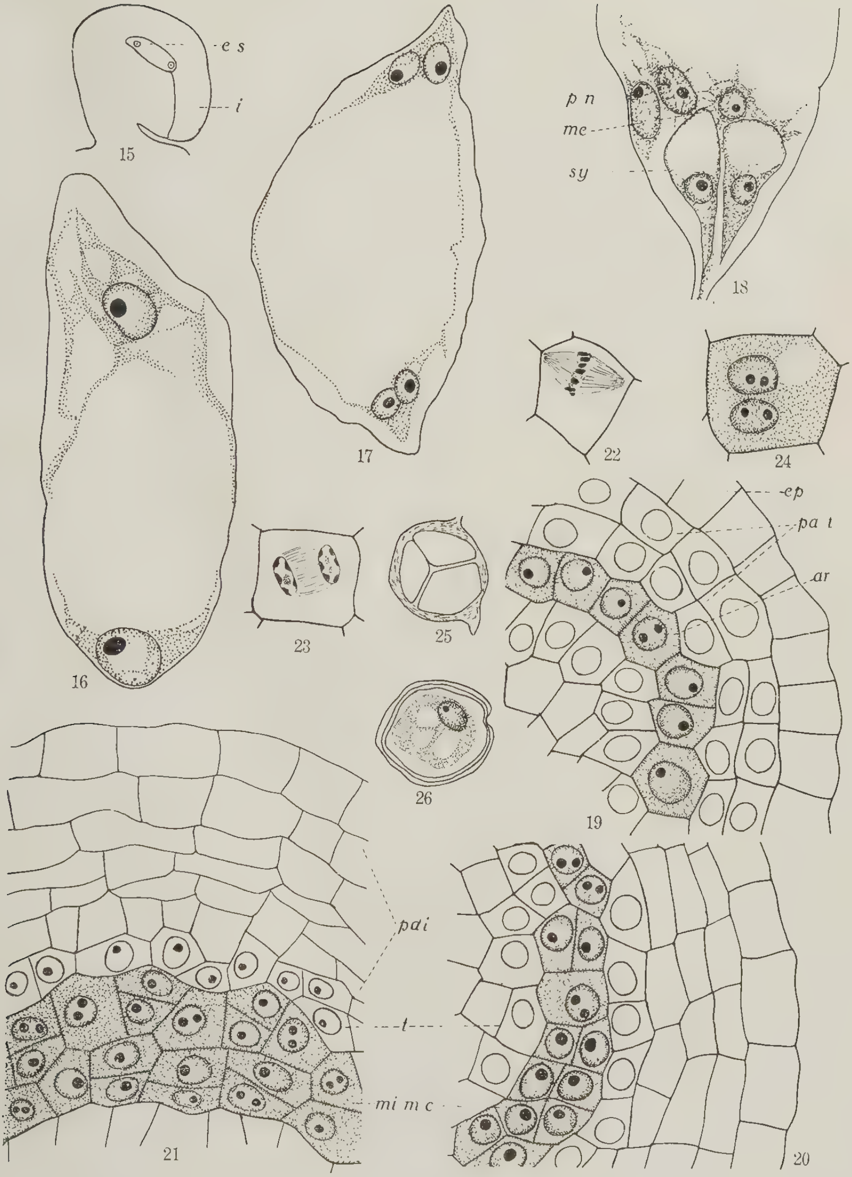
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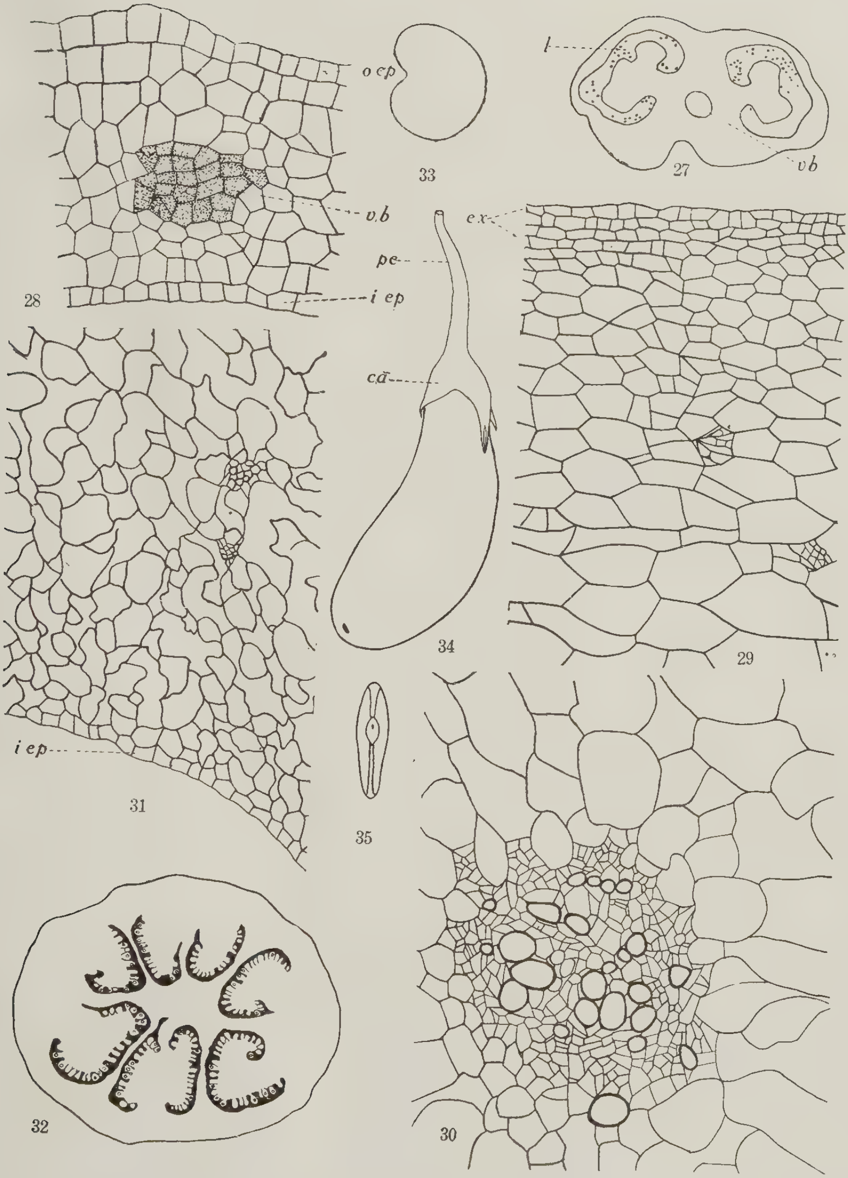
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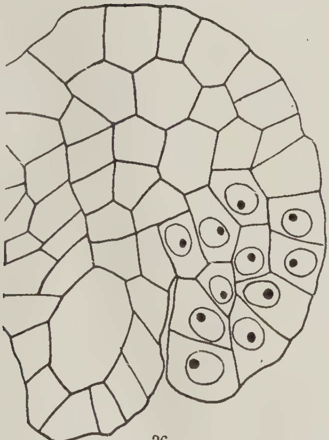

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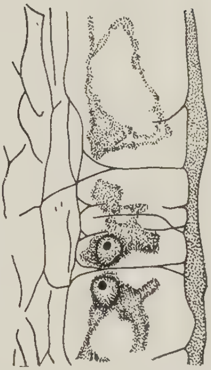

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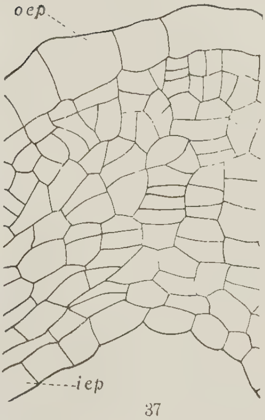

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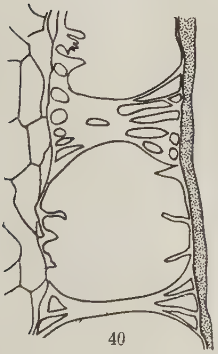

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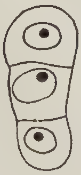

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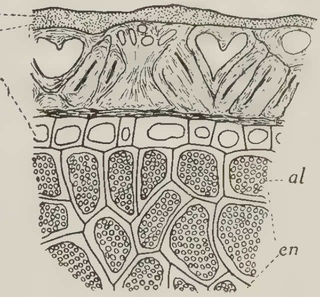

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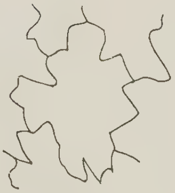

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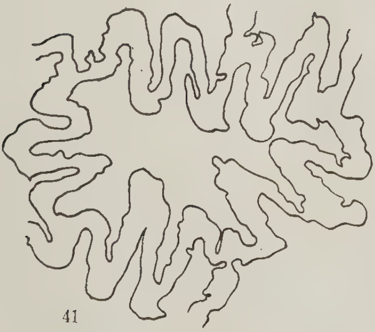

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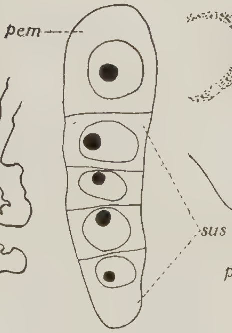

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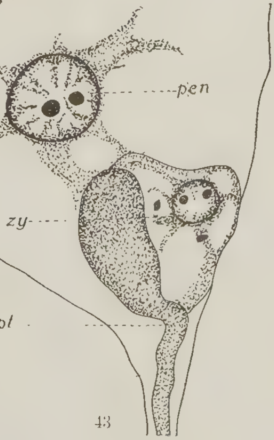

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PLATE 4

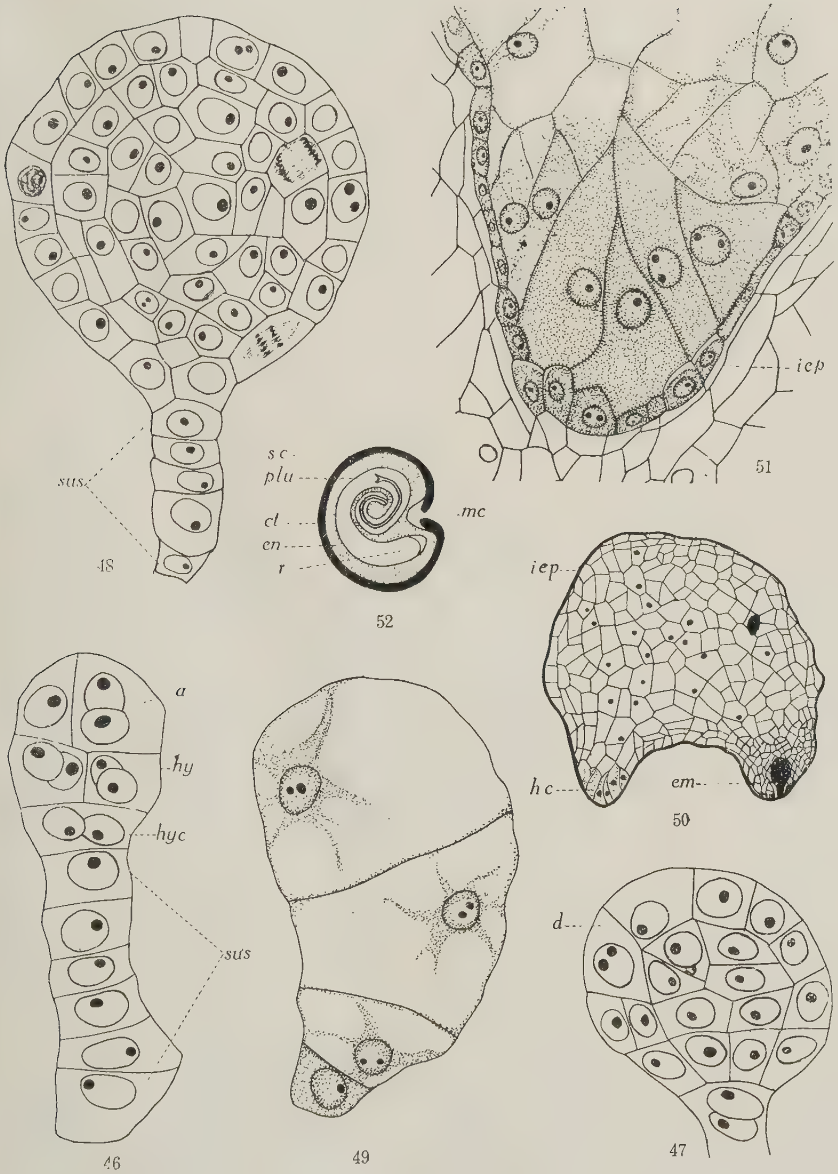
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PLATE 5

STUDIES ON THREE DIFFERENT KINDS OF SEED PIECES FOR COMMERCIAL PROPAGATION OF SUGAR CANE[1]

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One of the many factors that affect the yield of sugar cane is the kind of seed piece used. If the farmer knew the right kind of seed piece to use to obtain the maximum yield, he might economize on this item and lower his cost of production. Also, in experimental work, as in variety test of sugar cane, the factor of uniform seed pieces is very important in securing reliable results. In comparing new promising varieties with standard ones, oftentimes cut-back seed pieces and lalas[2] are used with the new varieties because of the limited supply of these planting materials, while with the standard varieties only top seed pieces are used.

In early plantings, farmers have now adopted the use of cut-back seed pieces secured from special plantings for propagation purposes. In ordinary planting, that is, when harvesting and planting are done simultaneously, in addition to tops, cut-back seed pieces prepared from immature cane stalks at the time of harvesting are also utilized as seeds. Most of the early and profusely flowering varieties, as POJ 2878, produce one to three or more side shoots or lalas at the terminal or just below the terminal portion of the cane stalk at maturity. This character impairs the value of tops for planting. However, the lalas can be utilized as planting materials in the absence of tops.

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[1] The junior authors each presented a thesis on a special problem on sugar cane seed pieces for graduation by the College of Agriculture in 1934. In this paper, the senior author has combined, with some additional data, the important results given in these theses. Experiment Station contribution No. 1114; theses Nos. 492 and 493.

Read before the Los Baños Biological Club on March 7, 1935; Received for publication July 10, 1935.

[2] In flowering varieties of sugar cane as POJ 2878, after flowering, the eyebuds at the upper nodes sprout and grow into short-jointed very woody side shoots containing numerous eyes. These side shoots which are used as seeds are locally known in Hawaii as "lalas". With the cultivation of the flowering varieties of sugar cane in the Philippines the word is coming into use in this country.

REVIEW OF LITERATURE

Body or cut-back seed pieces have been utilized as seeds. In Java, Quintus (1923) reported that stems about six months old coming from nurseries are utilized as seeds. The same general practice is followed in India, according to Butler (1907), who reported that the whole cane was cut into lengths containing, usually, three joints. In the Philippines, Hines (1918) stated that where planting material is scarce, immature portions of the cane stalk six to eight months old can be used with success. He also stated that the top part of the cane where the buds are capable of germinating contains the most water and invert sugar which serve as food for the developing buds. Reyes (1933) found that cut-back seed pieces gave fairly good germination, ranging from 67 to 85 per cent.

There are a few reports on the comparative merits of the different sizes of seed pieces of sugar cane. Reyes (1923) reported that short points with six buds or less and long points with ten or more buds gave similar results. Lee and Medalla (1928) contend that the larger the size of seed piece the better the germination. They also contend that under low soil moisture the more eyes a seed piece has the better the germination and hence the better the yield.

Alhama (1932) found that long seed pieces gave a higher percentage of germination than short seed pieces. He also found that in the first few weeks of life seedlings from long seed pieces attained a greater height than those from short seed pieces. He further stated that seedlings from long seed pieces were more vigorous than those from short seed pieces.

Studies have also been conducted on the comparative merits of the different portions of the cane stalk when used as seeds. In Louisiana, Stubbs (1915) reported that after thirteen years of experimentation the average yields from "tops", "middles", and "butts" were so nearly the same as to eliminate preference for any portion of the stalk as seeds.

In the Philippines, the senior author (1933) working on POJ 2878 cane variety found that top seed pieces gave a higher percentage of germination than the cut-back seed pieces, whether they were soaked or not in different media. It was also found that the top produced more tillers but less vigorous plants than the cut-back seed pieces.

Got (1933) was able to secure excellent planting materials by cutting back the top seed pieces of cane at the age of 6 to 10 months and allowing the eyes to develop to a length of 12 to 24 inches. He reported that these shoots or sprouts from the germinating eyes were particularly adapted for early planting in August, September and October.

It appears from this review of literature that the comparative merits of top and cut-back seed pieces have not been studied thoroughly. Also, there is no information on the comparative value of lalas and cut-back seed pieces, hence the work herein reported was undertaken.

OBJECTS OF THE PRESENT WORK

The investigation here reported had for its objects the following: (*a*) to determine the comparative germinatoin[3] and stand[4] of plants, of top and cut-back seed pieces, and also of lalas and cut-back seed pieces; (*b*) to determine the comparative degree of tillering of plants of top and cut-back seed pieces, and also of lalas and cut-back seed pieces; and (*c*) to determine the comparative yields of canes and sugar of plants of top and cut-back seed pieces, and also of lalas and cut-back seed pieces.

TIME AND PLACE

The work was performed in the Experiment Station of the College of Agriculture, University of the Phliippines. The study on the comparative merits of top and cut-back seed pieces was carried from October, 1932 to March, 1934, covering a period of about 17 months; the study on the comparative value of lalas and cut-back seed pieces from December, 1932 to January, 1934, covering a period of about 13 months.

MATERIALS AND METHODS

Comparative merits of the top and cut-back seed pieces.

Sugar cane fields and planting materials used. Two separate fields were used; one which has an area of 4,905 sq. m. for POJ 2878 and one with an area of 4,948 sq. m. for N. G. 24-A. The fields are level and the soil is clay loam. Top and cut-back seed pieces of POJ 2878 and N. G. 24-A were used.

Preparation of the land. The fields were plowed four times and harrowed after each plowing, using a native plow and a native harrow. Furrows one meter apart were made just before planting by passing the plow twice along the furrow.

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[3] Germination as used in this paper, refers to the stage when the shoots appear above the soil.

[4] The stand of plants was determined after the plants had passed through the dry months of April and May.

Laying of plots. The field planted with POJ 2878 was divided into two plots. The plot planted with top seed pieces had an area of 1,725 sq. m. and the one planted with cut-back seed pieces, 3,680 sq. m.

The field planted with N. G. 24-A was divided into three lots each of which was subdivided into plots. The first lot, which had an area of 2,400 sq. m. was sub-divided into four plots, two with an area of 500 sq. m. each, and two with an area of 700 sq. m. each. The second lot, which had an area of 1,768 sq. m., was also subdivided into four plots, two with an area each of 366 sq. m., and two with an area each of 488 sq. m. The third lot, which had an area of 840 sq. m., was divided into two plots, each with an area of 420 sq. m.

Preparation of tops. Stalks of POJ 2878, six to eight months old, and stalks of N. G. 24-A, eight to nine months old, were used. A piece from 30 to 35 cm. long of the topmost portion of each stalk was cut off and used as the top seed piece. The top seed pieces of POJ 2878 had three to six and N. G. 24-A four to seven eyes.

Preparation of cut-back seed pieces. The seed pieces obtained from the stalk just after removing the tops were considered cut-back, or body seed pieces. The cut-back seed pieces were prepared in the usual way, each measuring from 30 to 35 cm. In the case of POJ 2878 the cut-back seed pieces had each two to three eyes. of N. G. 24-A, two to five.

Planting. The POJ 2878 seed pieces were planted on October 9, 1932 and those of N. G. 24-A on December 16, 1932. The seed pieces were planted at the same time in each replication to minimize experimental error. The seed pieces were planted 75 cm. apart in the row. They were arranged in quincunx, that is, the hills in the second row formed the vertexes of isosceles triangle with those in the first furrow and so on.

Comparative merits of lalas and cut-back seed pieces.

Sugar cane field and planting materials used. The field used had an area of 0.7424 hectare. The soil is clay loam. Lalas and cut-back seed pieces of POJ 2878 were used.

Laying out of plots. The field was divided into four lots, each of which was sub-divided into plots. The first lot was divided into four plots, each with an area of 344 sq. m. The second lot was divided into four plots, each with an area of 352 sq. m. The third lot was divided into six plots, each with an area of 440 sq. m. The fourth lot was divided into two plots, each with an area of 1,000 sq. m. The plots were numbered from 1 to 16 and the odd-numbered plots were planted to lalas and the even-numbered to cut-back seed pieces.

Preparation of lalas. The upper portion of the flowered cane stalk containing sprouted buds or shoots called lalas was cut from the main stalk. The leaves were trimmed off to prevent excessive transpiration. The lalas were prepared by cutting diagonally between the nodes so that each lalas had one node of the parent stalk.

Preparation of cut-back seed pieces. Cut-back seed pieces were prepared from immature canes about six months old. The stalks were cut close to the ground and then cut into pieces diagonally, each varying in length from 25 to 30 cm., and each containing two to four or more eyes.

Planting. Lalas and cut-back seed pieces were planted at the same time in each replication to minimize error as much as possible. The seed pieces were set 75 cm. apart in rows which were laid 100 cm. apart. The hills were arranged in quincunx.

Cultivation, weeding and care of cultures. The canes were cultivated whenever it was found necessary. Cultivation was an alternate hilling-up and off-barring, and the final cultivation was hilling-up or closing-in. The weeds that were left between the hills were pulled up or cut off; sometimes they were dug up with a hoe.

Field observations. The percentage of germination, percentage of stand, tillering, vigor of plants, resistance to drought, diseases and pests, earliness of maturity and the relative abundance of weeds in the different plots were observed.

Harvesting and determination of yields. The canes were harvested and the weight of the canes from the different lots was recorded separately. The mixed juice of cane from the different lots was analyzed. The analysis were made in the College Sugar Mill with the help of Dr. Getulio Guanzon in charge of Sugar Technology Division of the Department of Agricultural Chemistry.

Only the millable stalks were harvested and milled. A cane stalk that measured one meter or more from the ground to the last visible node was considered a millable stalk, and a stalk less than one meter from the ground to the last visible node was considered nonmillable.

RESULTS AND DISCUSSION

The results of the study on top and cut-back seed pieces are presented in tables 1-4.

Field Observations

It was observed that in N. G. 24-A the tops germinated earlier than the cut-back seed pieces. The tops began to germinate 10 days after planting, the cut-back seed pieces in 13 to 16 days. Sixteen days after planting most of the tops had germinated, and 26 days after planting, most of the cut-back seed pieces. That the tops germinated earlier than the cut-back seed pieces may be due to the difference in their composition. Hines (1918) stated that the tops contain more water and invert sugars than the lower portion of the cane stalk; hence, the germination is faster.

In both varieties used, it was observed that there were more weeds in plots planted to cut-back than in those planted to top seed pieces. This condition may have been due to the higher percentage of missing hills in the lots planted to cut-back seed pieces than in those planted to tops, consequently, larger spaces for weeds. It was observed that the cut-back produced more vigorous plants than the top seed pieces. That there were wider spaces in plots planted with cut-back seed pieces than in those planted with tops, hence, less competition for the food nutrients in the soil may account, in part, for the greater vigor of plants developing from cut-back seed pieces.

Comparative germination of top and cut-back seed pieces

Table 1 shows the comparative germination of top and cut-back seed pieces of N. G. 24-A. It may be noted in table 1 that in all of the replications the tops had a better germination than the cut-back seed pieces. The tops gave an average of 14.66 per cent more germination than the cut-back seed pieces. The difference in germination may be ascribed in part to the difference in composition of the two planting materials. It may also be accounted for in part by the fact that the tops contained a greater number of eyes than the cut-back seed pieces. The points that did not germinate were examined and were found to be attacked by pineapple disease caused by *Ceratostomella paradoxa* Dade (*Thielaviopsis paradoxa* De Seyn. Von Hoehnel.) This disease may have increased the mortality. In an earlier study the senior author found that the low germination of cut-back seed pieces was due to the attack of pineapple disease. This result corroborates the findings of Calma (1933) that the tops had a better germination than the cut-back seed pieces. It also agrees with the findings of Lee and Quizon (1929) who reported that the percentage of germination of the whole seed piece was highest in case of ten-eye seed piece, next best was the three-eye seed piecé and the poorest was the two-eye seed piece.

Comparative stand of top and cut-back seed pieces

Table 2 shows the comparative stand of top and cut-back seed pieces. It may be seen in this table that in all of the replications the tops of N. G. 24-A gave a higher percentage of stand than the cut-back seed pieces. The average stand of the tops was 17.71 per cent higher than that of the cut-back seed pieces. It may also be seen in table 2 that the tops of POJ 2878 gave a stand 29.19 per cent higher than the cut-back seed pieces.

Comparative degree of tillering of plants grown from top and cut-back seed pieces

The data showing the comparative degree of tillering of plants grown from top and cut-back seed pieces are given in table 3. In this table it may be seen that in both varieties the top seed pieces produced more millable stalks than the cut-back seed pieces. In N. G. 24-A, in only one replication was there recorded for the tops a significant difference of millable stalks per stool superior to the cut-back; this difference was 0.69 ± 0. 16. In four out of five replications the difference was insignificant. This table also shows that in N. G. 24-A, the tops produced more non-millable stalks than the cut-back seed pieces. In only two out of the five replications were there significant differences.

The table shows that in POJ 2878 the tops produced 1.07 ± 0.13 more millable stalks than the cut-back seed pieces. This difference was significant. The cut-back seed pieces, however, produced 1.00 ± 0.13 non-millable stalk more than the tops. This difference was significant.

Comparative yields of cane and sugar of top and cut-back seed pieces

Table 4 shows the comparative yields of cane and sugar of top and cut-back seed pieces. It may be noted in this table that in the production of canes per hectare, the top and cut-back seed pieces did not have a marked difference. In N. G. 24-A, the mean yield of the tops was 74.2012 ± 5.8631 tons cane per hectare and of the cut-back seed pieces, 59.7338 ± 4.6547, giving an insignificant mean difference of 14.4674 ± 7.4861 tons per hectare. In POJ 2878 the tops gave only 6.2626 tons cane per hectare more than the cut-back seed pieces.

This table shows that the tops gave a yield of 123.9852 ± 7.1394 piculs sugar per hectare, and the cut-back seed pieces 105.83 ± 4.8826 piculs, giving an insignificant mean difference of 18.1552 ± 8.7901 piculs. In POJ 2878 the top seed pieces gave a yield of 14.0296 piculs sugar per hectare more than the cut-back.

From the data in this table it is obvious that the top and cut-back seed pieces did not have a marked difference in the production of picul sugar per tone cane. In N. G. 24-A the cut-back seed pieces were superior to the tops by the mean difference of 0.1025 ± 0.1280 picul per ton; this difference is insignificant. In POJ 2878, the tops gave only 0.0588 picul sugar per ton cane more than the cut-back seed pieces.

The study of the comparative merits of lalas and cut-back seed pieces

The results of this study are presented in tables 5-8.

Field observations. Of seed pieces planted on December 18, 1932, the cut-back seed pieces began to germinate nine days after planting, the lalas within nine days. Most of the cut-back seed pieces had germinated 17 days after planting, and most of the lalas by 15 days.

With seed pieces planted on February 24, 1933, 10 days after planting there was an almost complete germination of the lalas, and in 19 days of the cut-back seed pieces. The slowness in germination of the cut-back as compared with those planted on December 18, 1932 was principally due to the dryness of the soil.

It was also observed that in plots planted on December 18, 1932, the weeds were about equally distributed in the plots of lalas and of cut-back seed pieces. In those planted on February 24, 1933, the lalas plots were the less weedy. The high percentage of missing hills in plots planted to cut-back seed pieces provided more space for weeds than in the lalas plots. This is worthy of note as of course the presence of weeds affects the yield.

Generally, plants of seed pieces that were planted on December 18 were observed to be of the same vegetative vigor, however, cut-back-seed pieces planted on February 24, produced larger and taller stalks than the lalas planted on the same date. The space left by missing hills may account for these larger and taller stalks in cut-back plots than in the lalas.

Plants of both lalas and cut-back seed pieces flowered at about the same time. Some of the plants of replanted hills did not flower.

Comparative germination of lalas and cut-back seed pieces

The effects of different dates of planting upon germination. Table 5 shows the comparative germination of lalas and cut-back seed pieces.

Observations in the field as recorded in this table reveal the fact that in plots planted on December 18, 1932 the cut-back seed pieces had a better germination than the lalas. In plots planted on February 24, 1933, however, the lalas gave the better germination. Examination of the seed pieces in some of the missing hills showed that pineapple disease was the cause of the death of some of the plants, especially the cut-back seed pieces. The drought in the early part of February may have been a cause of high percentage of mortality. Casupang (1933) reports that long drought and pineapple disease infection were partly responsible for the death of young cane plants. The senior author in a study in 1933 found that the same factors were responsible for poor stand of canes in the field.

The data in table 5 show that in seed pieces planted on December 18 the percentage of germination of lalas was lower by an average of 7.51 per cent than that of cut-back seed pieces.

It may be noted, however, in this table that in all of the four replications planted on February 24, 1933, the lalas gave a 36.35 per cent higher germination than the cut-back seed pieces. These results indicate that cut-back seed pieces are more susceptible to adverse conditions, as drought, than lalas. It is worthy of note also that pineapple disease infection was more severe in the February planting than in the December planting, probably because of the dry condition of the soil.

Comparative stand of lalas and cut-back seed pieces

Table 6 shows the comparative stand of lalas and cut-back seed pieces.

The data show that even after the plants had developed their own root systems the cut-back seed pieces planted on December 18 gave a stand 11.91 per cent better than the lalas.

It may be noted in the same table that in plots planted on February 24, 1933 the lalas gave an average increase of 38.36 per cent more than the cut-back seed pieces.

It is interesting to note that there was a direct relation between the results obtained from percentage of germination and from percentage of stand.

Apparently, the same explanation offered for the difference of results obtained on germination holds true for difference of percentage of stand.

Comparative degree of tillering of plants of lalas and cut-back seed pieces

Table 7 shows the comparative degree of tillering of plants of both lalas and cut-back seed pieces.

Comparison of the number of millable stalks. The data in table 7 show that in all of the seven replications the lalas gave a significantly larger number of millable stalks per stool than the cut-back seed pieces. The highest number recorded for lalas was an average of 5.52 ± 0.13 millable stalks per stool. The stools of cut-back seed pieces in the corresponding replication produced an average of 4.66 ± 0.18 millable stalks. That the maximum number of stalks for both lalas and cut-back seed pieces was observed in the same replication is worth noting.

It may also be seen in this table that an average of 4.74 ± 0.13 stalks per stool was the smallest number produced by lalas; for cut-back seed pieces an average of 3.57 ± 0.13 stalks per stool.

In all the replications, without exception, the results show that the lalas produced the largest number of stalks; the difference was signigicant. This result illustrates the superiority of the lalas over the cut-back seed pieces in the ability to produce stalks per stool. This superiority may be explained, perhaps by the number of nodes present on the basal portion of the lalas. Each node contains one eye. The number of eyes present in a number of nodes is, therefore, a great advantage to the lalas. The cut-back seed pieces contain only 2 to 4 nodes, hence, only 2 to 4 eyes.

Comparison of the number of non-millable stalks. By referring again to table 7 it may be seen that in all the replications, with but one exception, the lalas produced more non-millable stalks than the cut-back seed pieces. An average of 2.08 ± 0.10 per stool was the highest number of non-millable stalks produced by lalas. An average of 1.45 ± 0.09 non-millable stalks was the highest produced by cut-back seed pieces. An average of 1.21 ± 0.06 non-millable stalks per stool was the lowest produced by lalas, and 0.85 ± 0.06 by the cut-back seed pieces. The same explanation as for millable stalks may be offered for these results.

Comparative yields of cane and sugar of lalas and of cut-back seed pieces

Table 8 shows the comparative yields of cane and sugar of lalas and of cut-back seed pieces. It will be seen in this table that the lalas and cut-back seed pieces planted on December 18, 1932 showed the same yielding capacity on the basis of tons cane and piculs sugar per hectare and piculs sugar per ton cane. The lalas gave a mean yield of 31.2285 ±2.6649 tons cane per hectare and the cut-back seed pieces, 28.7207 ± 3.0229 tons. The mean difference of 2.5078 ± 4.0298 was insignificant. The lalas gave a mean yield of 60.8605 ± 5.0444 piculs sugar per hectare and the cut-back, 55.9933 ± 5.1702 piculs, with an insignificant difference of 4.8672 ± 7.2234 piculs. Likewise, the cut-back was 0.009 ± 0.1166 picul sugar per ton cane better than the lalas, an insignificant difference.

In the planting material used, the degree of variation in yield in tons cane and piculs sugar per hectare in the February planting was very marked. The lalas which gave a mean yield in tons cane per hectare of 31.5300 ± 2.4739 proved to be a higher yielder than the cut-back seed pieces, which gave a mean of 17.5530 ± 1.2378 tons cane per hectare. The mean difference of 13.9770 ± 2.7662 tons was significant. Likewise, the yield in piculs sugar per hectare obtained from both treatments followed the cane yield per hectare. The mean yield of lalas was 71.4683 ± 5.9734 piculs and that of cut-back seed pieces 37.3340 ± 8.0978 piculs sugar per hectare, with a significant mean difference of 34.1343 ± 10.0625 piculs per hectare. The lalas was, however, 0.1480 ± 0.1349 picul sugar per ton cane better than the cut-back, an insignificant difference.

SUMMARY

The results of the study on the comparative merits of top and cut-back seed pieces may be summarized as follows:

1. The percentage of germination of tops was found to be higher than that of the cut-back seed pieces.

2. The tops gave a higher percentage of stand than the cut-back seed pieces.

3. Although in both varieties the tops produced more millable stalks per stool than the cut-back seed pieces, in N. G. 24-A the difference was insignificant. The cut-back seed pieces of POJ 2878 produced more non-millable stalks per stool than the tops; the difference was significant.

4. In yields of cane per hectare there was an insignificant difference between the top and cut-back seed pieces. The tops of N. G. 24-A gave 14.4674 ± 7.4861 tons more cane per hectare than the cut-back seed pieces; but the tops of POJ 2878 gave only 6.2626 tons more cane per hectare than the cut-back seed pieces.

5. The tops of N. G. 24-A gave 18.1552 ± 8.7901 piculs more sugar per hectare than the cut-back seed pieces, an insignificant difference. The tops of POJ 2878 gave only 14.0296 piculs more sugar per hectare than the cut-back seed pieces.

6. The cut-back seed pieces of N. G. 24-A gave 0.1025 ± 0.1280 picul more sugar per ton cane than the top seed pieces. This difference is insignificant. The tops of POJ 2878 gave only 0.0588 picul more sugar per ton cane than the cut-back.

On the whole, the results show that there was no significant difference between the top and cut-back seed pieces as to cultural responses, yields of cane and sugar per hectare and piculs sugar per ton cane. In commercial planting, cut-back seed pieces may be used.

The results of the study on the comparative merits of lalas and cut-back seed pieces may be summarized as follows:

1. The percentage of germination of lalas was found to be lower in the December planting than in the February. The cut-back seed pieces gave an average of 7.51 per cent more germination than the lalas. However, in the cane planted in February the lalas gave 36.35 per cent more germination than the cut-back seed pieces. This means that in late planting lalas had a better germination than the cut-back seed pieces.

2. As regards the percentage of stand in both canes, when planted early, the cut-back seed pieces gave an average increase of stand 11.91 per cent better than the lalas. In late planting the lalas showed an increase of stand 38.36 per cent better than the cut-back seed pieces.

3. The plants from lalas produced more millable and non-millable stalks per hill than the plants of cut-back seed pieces. This superiority of lalas was manifested in both early and late plantings. The range in number of millable stalks produced by lalas was from 4.74 ± 0.13 to 5.52 ± 0.13 stalks. The plants of the cut-back seed pieces gave a range of 3.57 ± 0.13 to 4.66 ± 0.18 stalks per stool.

4. The lalas produced more non-millable stalks per stool than the cut-back seed pieces. An average of 2.08 ± 0.10 was the largest number of non-millable stalks produced by lalas. An average of

1.45 ± 0.09 non-millable stalks per stool was the largest number produced by cut-back seed pieces.

5. In the December planting the yields in tons cane per hectare of lalas and cut-back seed pieces did not give any significant difference. In the February planting, however, the lalas gave a significantly more yield in tons cane than the cut-back seed pieces.

6. In the February planting, plants from lalas gave a significant yield per hectare of 34.1343 ± 10.0625 piculs more than those from the cut-back seed pieces. In the December planting the difference was insignificant.

7. The difference in picul sugar per ton cane of the lalas and cut-back seed pieces was statistically insignificant.

8. In general, there was no significant difference as to cultural responses of the plants produced by lalas and those produced by cut-back seed pieces. In germination, rate of stand, and yields of cane and sugar, the lalas excelled that of the cut-back seed pieces in the February planting. Because of these advantages, it is concluded that at times of shortage of planting materials from canes which are profusely arrowing, the use of lalas may be resorted to with results of practical value.

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TABLE 1

Showing the comparative germination of top and cut-back seed pieces of N. G. 24-A

CULTURE NO.	KIND OF SEED PIECES	SEED PIECES Counted	 Germinated	GERMINATION	SUPERIORITY IN TOP GERMINATION
		number	*number*	*per cent*	*per cent*
1	Top	665	658	98.95	24.36
2	Cut-back	665	496	74.59	
3	Top	931	913	98.07	8.45
4	Cut-back	931	834	89.58	
5	Top	492	490	99.59	6.91
6	Cut-back	492	456	92.68	
7	Top	656	651	99.24	11.44
8	Cut-back	656	576	87.80	
9	Top	560	556	99.28	22.14
10	Cut-back	560	432	77.14	
Total					73.30
Average					14.66

TABLE 2

Showing the comparative stand of plants of top and cut-back seed pieces

NAME OF VARIETY	CULTURE NO.	KIND OF SEED PIECES	HILLS Counted	 Living	STAND	SUPERIORITY OF TOP IN STAND
			number	*number*	*per cent*	*per cent*
N.G. 24-A	1	Top	399	377	94.49	31.58
"	2	Cut-back	399	251	62.91	
"	3	Top	532	462	86.84	9.02
"	4	Cut-back	532	414	77.82	
"	5	Top	492	394	80.08	8.78
"	6	Cut-back	338	241	71.30	
"	7	Top	492	402	81.71	11.79
"	8	Cut-back	492	344	69.92	
"	9	Top	420	369	87.86	27.38
"	10	Cut-back	420	254	60.48	
Total						88.55
Average						17.71
POJ 2878	1	Top	1,195	905	75.13	29.19
"	2	Cut-back	2,720	1,266	46.54	

TABLE 3

Showing the comparative degree of tillering of plants of top and cut-back seed pieces

NAME OF VARIETY	CULTURE NO.	KIND OF SEED PIECES	AVERAGE NUMBER OF STALKS PER STOOL (100 STOOLS COUNTED)	
			Millable	Non-millable
N. G. 24-A	1	Top	5.72 ± 0.11	1.57 ± 0.09
”	2	Cut-back	5.03 ± 0.13	1.33 ± 0.09
	Difference		0.69 ± 0.16 Significant	0.24 ± 0.12 Insignificant
”	3	Top	5.55 ± 0.11	2.34 ± 0.11
”	4	Cut-back	5.31 ± 0.12	1.42 ± 0.08
	Difference		0.24 ± 0.16 Insignificant	0.92 ± 0.14 Significant
”	5	Top	5.37 ± 0.10	1.29 ± 0.08
”	6	Cut-back	5.07 ± 0.12	1.20 ± 0.08
	Difference		0.30 ± 0.16 Insignificant	0.09 ± 0.11 Insignificant
”	7	Top	5.40 ± 0.12	2.10 ± 0.12
”	8	Cut-back	5.09 ± 0.10	1.15 ± 0.08
	Difference		0.31 ± 0.16 Insignificant	0.95 ± 0.15 Significant
”	9	Top	5.72 ± 0.11	1.53 ± 0.10
”	10	Cut-back	5.57 ± 0.16	1.46 ± 0.09
	Difference		0.15 ± 0.19 Insignificant	0.07 ± 0.13 Insignificant
POJ 2878	1	Top	5.72 ± 0.09	2.39 ± 0.08
”	2	Cut-back	4.65 ± 0.10	3.39 ± 0.10
	Difference		1.07 ± 0.13 Significant	1.00 ± 0.13 Significant

TABLE 4

Showing the comparative yields of cane and sugar of plants of top and cut-back seed pieces

VARIETY NAME	CULTURE NO.	KIND OF SEED PIECES	WEIGHT OF CANE	CALCULATED YIELD PER HECTARE OF		SUGAR PER TON CANE
				cane	sugar	
			tons	*tons*	*piculs*	*piculs*
N. G. 24-A	1	Top	4.140	82.8000	114.0566	1.3775
”	2	Cut-back	2.862	57.2400	102.4752	1.7902
”	3	Top	6.892	98.4571	164.5858	1.6716
”	4	Cut-back	5.807	82.9571	134.4770	1.6210
”	5	Top	2.039	55.7100	100.1757	1.7982
”	6	Cut-back	2.392	65.3552	97.0539	1.4850
”	7	Top	3.964	81.2295	122.9300	1.5134
”	8	Cut-back	2.455	50.3074	98.7350	1.9626
”	9	Top	2.218	52.8095	118.1780	2.2378
”	10	Cut-back	1.798	42.8095	96.4086	2.2521
	Average	Top		74.2012 ± 5.8631	123.9852 ± 7.1394	1.7197 ± 0.0997
	”	Cut-back		59.7338 ± 4.6547	105.8300 ± 4.8826	1.8220 ± 0.0803
	Difference			14.4674 ± 4.6547	18.1552 ± 8.7901	0.1025 ± 0.1280
				Insignificant	Insignificant	Insignificant
POJ 2878	1	Top	7.374	42.7478	81.1945	1.8996
”	2	Cut-back	13.427	36.4852	67.1649	1.8408
	Difference			6.2626	14.0296	0.0588

TABLE 5

Showing the comparative germination of "lalas" and cut-back seed pieces

DATE PLANTED	CULTURE NO.	KIND OF SEED PIECES	SEED PIECES			SUPERIORITY IN GERMINATION OF	
			Counted	Germinated	Germination	cut-back	lalas
			number	*number*	*per cent*	*per cent*	*per cent*
12–18–32	1	Lalas	456	295	64.67	—	—
"	2	Cut-back	456	366	80.26	15.59	—
"	3	Lalas	456	314	68.85	—	—
"	4	Cut-back	456	342	75.00	6.15	—
"	5	Lalas	456	355	75.85	—	—
"	6	Cut-back	456	382	81.62	5.77	—
"	7	Lalas	351	235	66.95	—	—
"	8	Cut-back	351	244	69.51	2.56	—
2–24–33	9	Lalas	585	318	54.35	—	—
"	10	Cut-back	585	159	27.18	—	27.17
"	11	Lalas	585	464	79.31	—	—
"	12	Cut-back	585	226	38.63	—	40.68
"	13	Lalas	585	457	78.11	—	—
"	14	Cut-back	585	200	34.18	—	43.93
"	15	Lalas	1320	827	62.65	—	—
"	16	Cut-back	1320	373	29.01	—	33.64
Total						30.07	145.42
Average						7.52	36.35

TABLE 6

Showing the comparative stand of plants of "lalas" and cut-back seed pieces

DATE PLANTED	CULTURE NO.	KIND OF SEED PIECES	HILLS		STAND	SUPERIORITY IN STAND OF	
			Counted	Living		cut-back	lalas
			number	*number*	*per cent*	*per cent*	*per cent*
12–18–32	1	Lalas	456	242	53.07	—	—
"	2	Cut-back	456	341	74.78	21.71	—
"	3	Lalas	456	251	55.04	—	—
"	4	Cut-back	456	284	62.28	7.24	—
"	5	Lalas	456	204	44.73	—	—
"	6	Cut-back	456	269	57.47	12.74	—
"	7	Lalas	351	160	45.58	—	—
"	8	Cut-back	351	181	51.56	5.98	—
2–24–33	9	Lalas	585	265	45.29	—	—
"	10	Cut-back	585	103	18.01	—	27.28
"	11	Lalas	585	410	70.08	—	—
"	12	Cut-back	585	177	30.25	—	39.83
"	13	Lalas	585	410	70.08	—	—
"	14	Cut-back	585	118	20.01	—	50.07
"	15	Lalas	1320	800	60.60	—	—
"	16	Cut-back	1320	321	24.31	—	36.29
Total						47.67	153.47
Average						11.91	38.36

TABLE 7

Showing the comparative degree of tillering of plants of "lalas" and cut-back seed pieces

CULTURE NO.	KIND OF SEED PIECES	AVERAGE NUMBER OF STALKS PER STOOL IN 100 STOOLS	
		Millable	Non-millable [a]
1	Lalas	5.04 ± 0.14	1.21 ± 0.06
2	Cut-back	4.36 ± 0.15	0.98 ± 0.09
Difference		0.68 ± 0.21 Significant	0.23 ± 0.11 Insignificant
3	Lalas	5.23 ± 0.13	1.21 ± 0.08
4	Cut-back	3.89 ± 0.11	0.85 ± 0.06
Difference		1.34 ± 0.17 Significant	0.36 ± 0.10 Significant
5	Lalas	4.74 ± 0.13	1.61 ± 0.09
6	Cut-back	4.07 ± 0.14	1.08 ± 0.08
Difference		0.67 ± 0.19 Significant	0.53 ± 0.12 Significant
7	Lalas	5.39 ± 0.17	1.44 ± 0.09
8	Cut-back	3.88 ± 0.14	1.03 ± 0.07
Difference		1.51 ± 0.22 Significant	0.41 ± 0.12 Significant
9	Lalas	5.25 ± 0.13	1.91 ± 0.08
10	Cut-back	3.57 ± 0.13	1.45 ± 0.09
Difference		1.68 ± 0.18 Significant	0.46 ± 0.12 Significant
11	Lalas	5.41 ± 0.12	2.08 ± 0.10
12	Cut-back	3.90 ± 0.17	1.45 ± 0.09
Difference		1.51 ± 0.20 Significant	0.63 ± 0.14 Significant
13	Lalas	5.52 ± 0.13	1.70 ± 0.08
14	Cut-back	4.66 ± 0.18	1.53 ± 0.10
Difference		0.86 ± 0.23 Significant	0.17 ± 0.13 Insignificant

[a] Suckers or shoots less than a meter high from the last visible node were considered as non-millable in this study.

TABLE 8

Showing the yields of cane and sugar of plants of "lalas" and cut-back seed pieces

DATE PLANTED	KIND OF SEED PIECES	CALCULATED YIELD PER HECTARE OF		SUGAR PER TON CANE
		canes	sugar	
		tons	*piculs*	*piculs*
12-18-32	Lalas	31.2285±2.6649	60.8605± 5.0444	1.9557±0.0890
	Cut-back	28.7207±3.0229	55.9933± 5.1702	1.9653±0.0754
	Difference	2.5078±4.0298 (Insignificant)	4.8672± 7.2234 (Insignificant)	-0.0096±0.1166 (Insignificant)
2-24-33	Lalas	31.5300±2.4739	71.4683± 5.9734	2.2620±0.0470
	Cut-back	17.5530±1.2378	37.3340± 8.0978	2.1140±0.1349
	Difference	13.9770±2.7662 (Significant)	34.1343±10.0625 (Significant)	0.1480±0.1349 (Insignificant)

THE RELATION OF THE DEGREE OF POLLINATION TO THE PRODUCTION OF COVERED AND EXPOSED TIPS OF CORN EAR[1]

Marcelino B. Plurad

WITH TWO TEXT FIGURES

The appearance of the ears affects the market value of corn. Well-filled ears are usually preferred because the amount of shelled grain is more than that from the partly-filled ears of the same size and strain. Generally, seed corn for planting is selected from well-filled ears for it is a belief among farmers that these ears are better yielders than the partly filled ones.

In the Philippines, so far as the writer knows, no experimental work on the agronomic values of covered and exposed tips of corn ear has been reported. In the United States it has been reported by Williams and Welton (1915), Hartley and Garrison (1921), Lindstrom (1923) and Salmon (1926) that there was no apparent or significant difference between the yield of corn ears with well-filled tips and those with exposed tips.

The work herein reported was undertaken with two specific objects; namely, (*a*) To determine the effect, if any, of the degree of pollination upon the production of corn ears with either covered or exposed tips. (*b*) To study the possibility of producing well-filled and partly filled ears by regulating the amount of pollen supply.

The work was conducted on the Experiment Station farm and in the Plant Breeding Laboratory of the Department of Agronomy, College of Agriculture, University of the Philippines, from October, 1932 to February, 1934, covering a period of 17 months.

MATERIALS AND METHODS

Varieties used

Two strains of a native variety of corn were used in this study, the Los Baños Yellow strain and the Abra strain, both of the Native

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[1] Thesis presented for graduation, 1934, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 495; Experiment Station contribution No. 1115. Prepared in the Department of Agronomy under the direction of Dr. J. M. Capinpin.

Yellow Flint variety. The Abra strain is lighter in color, more plump, has larger cob, and is softer in texture than the Los Baños strain. The Abra strain was introduced into the College in October, 1932 by the writer. The Los Baños strain was secured from the Farm Management Division of the Department of Agronomy.

Selection of materials. Fifty ears with covered tips and fifty ears with exposed tips were selected from each strain. Selection was made just after the ears were harvested.

Measurement of exposed tips. Ears which had more than one centimeter of exposed tips (bare cob) were considered "exposed" and all those with entirely covered tips were considered "covered", with the exception of the Los Baños strain, a few ears of which with less than one centimeter of exposed tips were considered as covered because of lack of available materials at the time the experiment was started.

The length of the ears and exposed tips were measured with a wooden caliper calibrated in centimeters. The relation of exposed cob to filled portion of the ear was reduced to a quantity, which in a fully filled ear is equivalent to 1. By subtracting the length of the filled portion of the ear from the length of the entire ear (length of cob) the length of the unfilled portion was obtained. And by dividing the length of the ear by the length of the filled portion, a certain value was found which in case of covered ears is equal to 1 and in the exposed ear a value greater than 1.

Analysis of individual ears. The ears were weighed separately in a Cenco balance. Then they were shelled and the weight of the shelled grains determined. The quotient of these weights multiplied by 100 expresses the shelling percentage of the individual ears.

Preparation of the land. The fields were prepared in the ordinary way. They were plowed three times and harrowed once after each plowing. The first plowing was just after harvesting the crop planted previous to the experiment, the second plowing three to four weeks later, and the third plowing a day or two before planting.

Planting

In this study, two plantings were made, one for the rainy season and another for the dry season. These two plantings were conducted in adjacent fields. The vacant lots in the orchard rows of the Agronomy Department were used.

Dry season planting. For the dry season culture, two lots, each measuring an area of 1,050 square meters or 0.105 hectare were used. One lot was planted to the Abra strain and the other lot to the Los Baños strain.

Planting was on November 17, 1932 which was rather late because of the unfavorable weather conditions at the time the study was conducted. The rate of seeding was 5 kernels to the hill; hills, 75 centimeters apart. The missing hills were replanted two weeks later. As this time, some seedlings showed symptoms of downy mildew (*Sclerospora philippinensis* Weston) because of the very unfavorable weather conditions. The attacked seedlings were immediately rogued out and thrown into a pit. Thinning was done gradually day by day until the field was reduced to a uniform stand of two plants to a hill.

The two strains were planted separately in adjoining field plots. The covered and exposed tips of the Abra strain and also the Los Baños were planted alternately, two rows of covered tips, then two rows of exposed tips.

Wet season planting. The area used in the wet season culture was 2,122 square meters (0.2122 hectare) which is approximately double that of the dry season. After the field was thoroughly prepared, it was divided into four lots, giving an allowance of two meters between each lot. Each lot was further subdivided into plots of 30 square meters (3 × 10 meters) each, making 12 plots to a lot, with an allowance of one meter between plots. In each plot, four rows one meter apart were made. The first lot was planted to Abra covered tips, the second lot to Abra exposed tips, the third lot to Los Baños exposed tips and the fourth lot to Los Baños covered tips.

The materials used in the wet-season planting were taken from the dry-season harvest. Planting was done on May 31, 1933. The rate of seeding, depth of planting and rate of distancing were the same as in the dry season planting. Three days after sowing, the seeds began to germinate and a week later the shoots of the seedlings which germinated were fully out. First thinning was begun two weeks after sowing. The plants were thinned to a uniform stand of three plants to a hill, and a month after planting the plants were further thinned to two. In thinning, the weak, slender and sickly looking plants were pulled out. The rows in each plot were then labeled according to the treatment they received.

Treatment of each plot

As stated elsewhere in this paper, the covered and exposed tips of both strains were planted alternately, that is, two rows of covered tips alternated with two rows of exposed tips, one row to be treated and the other row to be left untreated. The rows were divided into four portions each portion receiving different treatments in the following manner: (*a*) detasseled, (*b*) with tassel and hand-pollinated, (*c*) detasseled, hand pollinated, and (*d*) no treatment. When a row of covered tips was treated in the order enumerated above. the adjacent row of exposed tips was treated in the same manner and the next rows of covered and exposed tips were treated in the reverse order.

As the planted field was divided into plots in quadruplicate during the wet season planting, the treatment given to plots was in a checkerboard manner. There were four rows in one plot. Alternate rows were treated and the rest served as control, so that every treated row had its own control, unlike the dry season culture in which there was a separate plot for the control. The treatment given to the plots was the same for both strains studied, either with covered or with exposed tips.

In both the dry and wet season culture, detasseling was done as soon as the tips of the tassels were out, pulling them out gradually with much care so as not to injure the leaves.

Methods of pollination

Bagging was not practised in this study. At first the writer tried the dusting method used by Collins and Kempton (1911). The pollen grains from adjacent rows or those of the plant to be pollinated were collected in a vial. By shaking the tassel, the pollen grains were conveyed into the vial through a funnel made of oiled paper. When enough pollen grains were collected a piece of fine cheese cloth was tied securely with a rubber band around the mouth of the vial. This method was so tedious that the writer was not able to pollinate all the plants whose slik was out in the treated plots between 7:30 and 10:00 o'clock in the morning when the greatest amount of pollen grains were being shed. Besides, dusting could not be done effectively because the morning dew, upon shaking, fell into the vial thus making the pollen grains stick together. Because of these draw-backs the method used by Kiesselback (1922) was then tried. By this method the pollen grains were collected in a Manila paper bag which was inverted over the silk. Pollination was more effective by this method. These methods were used during the dry-season culture.

The second method was employed also during the wet-season culture but one objection to it was that early in the morning the leaves and tassels were wet with dew so that in collecting the pollen grains being wet stuck to the bag. A more practical method was then adopted. Part of the rachillae with spikelets containing mature pollen grains was clipped off and held in one hand and with the silk in the other hand, the clipped spikelets were shaken over the silk and the pollen grains were discharged. This method was faster than either of the other two used. One great disadvantage, however, is that those spikelets on the clipped portion of the rachilla which were not opened were wasted.

Both strains were pollinated every day for a period of three weeks. Each plant was pollinated at least three times, to make sure that the plants were amply supplied with pollen.

During the wet season, pollination was at first delayed because the tassels and silk of the plants, especially the Abra strain along the road, were severely attacked by a beetle (*Monolepta bifasciata* Hornst). On August 1, 1933, just at the time when pollination was over, a very strong wind swept the whole field, thus causing most of the plants to fall down, especially those of the Abra strain.

Harvesting

During the dry season the Abra strain was harvested on February 17, 1932, 92 days after planting and the Los Baños strain on March 13, 1932, 116 days after planting. The treated rows were harvested first, placing the ears of each treatment in a sack and labeling it properly. Harvesting was done by snapping the ears from the stalk. The harvest was brought to the Laboratory where the ears were husked, dried for about two weeks in the laboratory and in the sun. Then the ears were classified into nubbins and good ears. The good ears were measured, weighed and shelled, as was done with the original planting materials.

The wet-season crop of the Abra strain was harvested on August 26, 1933, 87 days after planting and that of Los Baños strain on September 16, 1932, 108 days after planting. The ears were brought into the laboratory where they were husked and bundled.

Each row under each treatment was bundled separately and labeled. The ears were then classified after drying and the lengths, weights and shelling percentages were determined as in th previous harvest.

EXPERIMENTS AND RESULTS

Field observations

In the dry-season culture, tasseling was observed on the Abra strain on December 23, 1932, 36 days after planting. Silking was first observed on December 29, 1932, six days after tasseling.

With the Los Baños strain, tasseling was first noticed on December 31, 1932, 44 days after planting and about a week later silking was first observed.

In the wet season culture, first tasseling was observed in the field of the Abra strain on July 6, 1933, 38 days after planting. Silking was first observed four days later. The Los Baños strain with covered tips first produced tassel on July 10, 1933, 41 days after planting and produced silk four days later. The Los Baños strain with exposed tips first produced tassels on July 15, 1933, 46 days after planting and silked five days later.

The results of the different treatments as affected by the degree of pollination to the production of covered and exposed tips of corn ears of the two strains used are given in the tables.

Tables 1a, 1b, 1c, and 1d present the mean percentages of exposed and filled tips and nubbins of both strains observed in both seasons of plantings. They also present the relative importance of the well filled and exposed tips.

Tables 2a and 2b present the relation of exposed cob to filled portion of the ears of both strains for both seasons of plantings.

DISCUSSION OF RESULTS

Agronomic characteristics of Abra and Los Baños strains

By inspection the ears of the two strains used may be easily distinguished. The ears of Abra strain are shorter than those of the Los Baños strain. The Abra strain had a typical length of 14 centimeters and the Los Baños strain, 17 centimeters. Although shorter, the covered ears of the Abra strain weighed heavier than those of the Los Baños strain. The exposed ears of the Los Baños strain was found to be heavier than the exposed ears of Abra strain. The Los Baños strain had a higher shelling percentage than the Abra strain. In both cases, and with special reference to this particular study the covered ears had a higher shelling percentage than the exposed ears.

Flowering and season of planting .

The general belief of the Filipino farmers is that corn plants begin to flower from four to five weeks after planting and that tasseling and booting coincide, regardless of the soil fertility. Under conditions obtaining where these observations were made, the writer found that the flowering and booting do not coincide, and that two distinct strains do not flower at the same time.

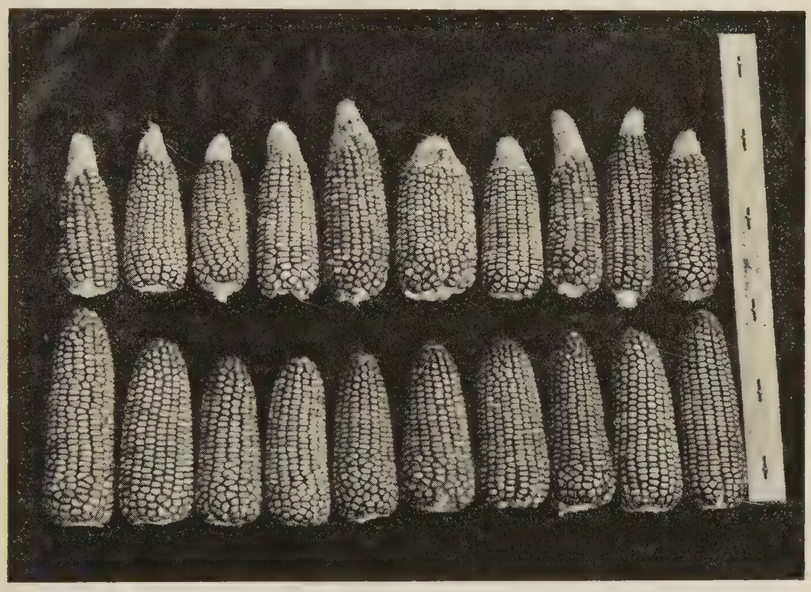

Fig. 1.—Showing the type of ears of Abra strain used in the study: upper row, with exposed tips; lower row, with covered tips.

It was observed that during the dry season, the Abra strain began to bear flowers 36 days after planting; and the Los Baños 44 days after planting.

The silking of the Abra strain was found to occur 44 days after planting in both seasons; and for the Los Baños strain, 52 days in dry season and 48 days in wet season.

In this study it was found that there was a slight difference between the flowering of corn plants planted in the dry season and those planted in the wet season. In the dry season, the Abra strain tasseled 36 days after planting and the Los Baños strain 44 days after planting. In the wet season, the Abra strain tasseled 38 days after planting and the Los Baños strain tasseled 43 days after planting.

With reference to silking, it was found that during the dry season, it took a longer time for the silk to appear than in the wet season. It requires an average length of time of 47 days for the dry season and an average length of time of 45 days for the wet season.

Anthesis and shedding of pollen grains

The corn flowers open early in the morning. It was noticed that its pollen grains begin to shed at 6:00 a. m. and the greatest amount of pollen grains shed from 7:30 to 10:00 a. m. On bright days dehiscence takes place as early as 6:00 o'clock and it continues to shed throughout the day. On cloudy days dehiscence is delayed, possibly by the lack of intensity of light.

The spikelets in the tassel do not open at the same time. They open from the top downward in a regular sequence, and all are open as soon as the tassel is fully out from the boot. This finding coincides with the conclusion of Kiesselback (1922) who stated that the upper portion of the central spikelet is the seat of the initial shedding of pollen and from it, it extends downward and laterally to the tassel branches.

Treatments employed and supply of pollen

According to the arrangement of the treatments employed, the different degrees of pollination were as follows: (*a*) detasseled, no treatment; this would depend on natural agencies of pollination; (*b*) with tassel, hand-pollinated: the pollen for this lot was supplied from natural agencies of pollination, that is, pollen coming from its tassel and from neighboring plants as well as those which were supplied artificially; (*c*) detasseled and hand-pollinated; this lot depended upon plants of neighboring rows as well as the pollen applied artificially; (*d*) no treatment, depended on natural agencies of pollination. Of these lot treatments, (*b*) received the greatest amount of pollen grains to be utilized for fertilization, the supply coming from the plant itself, the neighboring plants through natural agencies and the artificial supply of pollen. Next to this is treatment (*c*) which was detasseled, hand pollinated. The pollen supply of this came from the neighboring plot through natural agencies and the pollen artificially supplied. Treatment (*d*) or control received the natural supply of pollen, a condition to be met with in any ordinary corn field. Treatment (*a*) received the least supply of pollen for it depended mostly on neighboring plants through natural agencies.

Effects of the different degrees of pollination on the production of covered and exposed tips of corn ears

Reference to tables 1a to 1d will show that only the Abra ears with covered tips gave a significant difference in the production of ears with exposed tips in the detasseled plants and in the production of ears with filled tips in detasseled, hand-pollinated, and with tassel, hand-pollinated. All these significant differences were observed in the dry season culture of this strain. In the treatments where the plants were detasseled, the difference in percentage of exposed ears between the treated and the control was 9.02 ± 1.65 which is statistically significant. The treatment where the plants were detasseled but hand pollinated gave a difference of 9.79 ± 0.96, that of plants with tassel and hand pollinated was 9.70 ± 2.34. This result

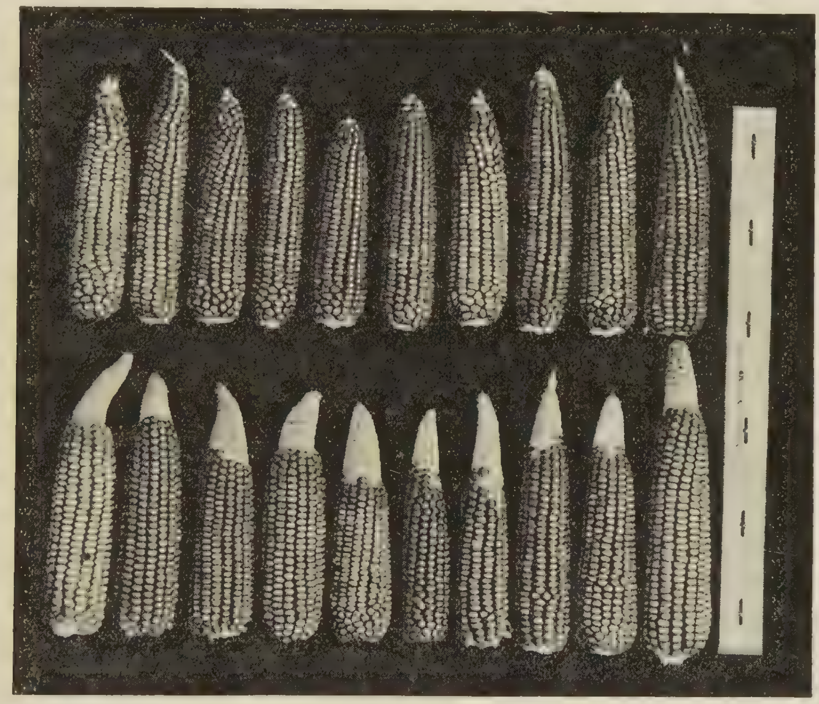

Fig. 2.—Showing the type of ears of Los Baños strain used in the study: upper row, with covered tips; lower row, with exposed tips.

was in line with the observation of Johnson and Hayes (1922) who found that the use of supplementary pollen gave an increase in yield of hybrid seeds. The production of nubbins was significant only in this same strain (Abra) and in the same season (dry season). This significant production of nubbins was in the case of the detasseled plants where the percentage difference of the mean of the treated and control was 10.33 ±2.60.

It is interesting to note that in the case of the detasseled plants under this same culture the percentage difference in the production of exposed tips between the mean of the treated and the untreated, that is, 9.00 ± 1.65 was significant. The result shows that such treatment was conducive to the production of exposed tips of ears in the dry season, using the covered ears of the Abra strain. In the case of the Los Baños strain such difference was insignificant.

In the dry-season culture of the Los Baños strain using ears with exposed tips for planting, there was no production of ears with filled tips. All plants under the different treatments including the control, produced ears with exposed tips and nubbins. The production of ears with exposed tips is insignificant in all the different treatments, the percentage difference between the mean of the treated and the control being 5.94 ± 3.12 in the case of the detasseled and hand pollinated, and 7.47 ± 19.16 in the case of the detasseled plants. In the dry-season culture of this same strain where ears with covered tips were used, the plants with tassel and hand-pollinated were supposed to produce filled tips but failed. In the other treatments (*b*), (*c*) and (*d*) the percentage production between the mean of the treated and the control in the production of exposed, filled and nubbins for all treatments was insignificant.

In the wet-season culture, there was no significant difference between the treated plants and the control in all lots. The production of a higher percentage of filled ears in the wet season probably explains why a heavier crop of corn is obtained. The production of superior ears may be due to the difference in humidity which is an important factor in the vitality of pollen grains.

In tables 1a and 1b for the Abra strain using the covered and exposed materials there was produced in the wet season 30 to 35 per cent of the crop with filled tips. In the dry season this percentage varied from 2 to 13 per cent. The Los Baños strain, on the contrary, produced from 3 to 23 per cent of the crop with filled ears in the wet season but almost none in the dry season. It may be safely concluded that the Abra corn strain produced comparatively more filled ears than the Los Baños strain. Another important point in this experiment was the production of a higher percentage of filled ears in the wet-season crop than in the dry-season crop.

Generally speaking, and considering only the percentages of the ears produced on exposed and on covered tips, it will be found that the treatment, with tassels and hand-pollinated, in both cultures, gave a higher percentage of filled ears and a lower percentage of exposed ears than the other treatments.

The production of covered tips from lot supposed to give perfect fertilization

The lots in which the plants were with tassel and hand-pollinated were supposed to give perfect fertilization. The percentage production of filled ears under dry season culture of the Abra covered tips is significant (table 1a, column 5). The percentage production of filled ears ranges from 13.20 ± 2.14 for the treated and 3.50 ± 0.95 for the control. With the Abra exposed tips (table 1b, column 5) the percentage of production of filled under dry season was 8.02 ± 2.85 for the treated and 2.22 ± 0.45 per cent for the control, giving a mean difference of 5.80 ± 2.89 which is insignificant.

With Los Baños covered and exposed tips grown during the dry-season culture (tables 1c and 1d) the percentage production of filled was zero. In other words, no ear with filled tips was produced.

In the case of the wet-season culture for both strains in all treatments the percentage of production of ears with filled tips was insignificant. The percentages of production of ears with filled tips range from 49.04 ± 4.67 for the treated and 40.64 ± 5.60 for the control or a difference of 8.40 ± 7.29 per cent for the Abra covered; 43.35 ± 3.73 for treated and 39.94 ± 4.22 for the control or a difference of 8.40 ± 7.29 per cent for the Abra exposed; 3.89 ± 0.85 for treated and 7.17 ± 1.46 for the control or difference of 3.25 ± 1.70 per cent for Los Baños exposed; and 17.55 ± 1.85 for treated and 23.69 ± 3.09 for the control, or a difference of 6.14 ± 3.61 per cent all of which are insignificant. It is to be noted, however, that with the Los Baños strain (covered and exposed tips) the production of ears with filled tips was more in the control than in the treated plots, in all cases.

The ratio of filled ears is expressed quantitatively as 1 and the ratio of non-filled to filled portions of the ear as more than 1 (fig.

1). Therefore, the greater the ratio the greater is the length of bar tip or non-filled portions.

In the dry-season culture there were significant differences in lots (*b* and *c*) which received the greatest amount of pollen grains, except in Los Baños strain with covered tips which was lower than the control.

The ratios are for (1) detasseled and hand-pollinated 1.09 ± 0.003 for treated and 1.6 ± 0.020 for control or a difference of 0.65 ± 0.020 cm. which is significant, for Abra covered; 1.11 ± 0.023 for treated and 1.19 ± 0.010 for control, or a difference of 0.08 ± 0.025, which is significant for Abra exposed; 1.195 ± 0.016 for treated or 1.20 ± 0, or a difference of 0.005 ± 0.016, which is insignicant for Los Baños covered; and 1.24 ± 0.020 for treated and 1.30 ± 0.006 for control, or a difference of 0.06 ± 0.0066, which is also highly significant for Los Baños exposed. (2) With tassel and hand-pollinated, 1.055 ± 0.003 for created and 1.16 ± 0.020 for control, or a difference of 0.105 ± 0.020 cm., which is every significant for Abra covered; 1.09 ± 0.016 for treated and 1.195 ± 0.010 for control, or a difference of 0.10 ± 0.019 cm., which is significant for Abra exposed; 1.20 ± 0.006 for treated and 1.20 ± 0 for control which is insignificant for Los Baños covered; and 1.195 ± 0.003 for treated and 1.30 ± 0.006 or a difference of 0.105 ± 0.007 cm., which is very significant for Los Baños exposed. (3) Detasseled, 1.13 ± 0 for treated and 1.16 ± 0.020 for control, or a difference of 0.03 ± 0.020 cm., which is insignificant for Abra covered; 1.20 ± 0.016 for treated and 1.19 ± 0.010 for control, or a difference of 0.010 ± 0.019 cm., which is insignificant for Abra exposed; and 23 ± 0.006 for treated and 1.20 ± 0 for control, or a difference of 0.03 ± 0.006 cm., which is very significant for Los Baños covered; and 1.30 ± 0.013 for treated and 1.30 ± 0.006 for control, or a difference of 0.0 cm.

In the wet season cultures in all treatments for both Abra and Los Baños strains there was no significant difference in the relation of covered and exposed portions between the treated and the control.

Production of covered and exposed tips from plots originally planted to grains from covered and exposed tips

As may be seen from tables 1a to 1d for both wet- and dry-season cultures, both covered and exposed tips of either Abra strain or Los Baños strain produced ears with filled and exposed tips, except in Los Baños exposed tips grown during the dry-season where no filled ears were produced in all the treated plots. During the wet season, this strain produced filled and non-filled tips as well. The range of production of exposed tips was from 38.98 ± 13.81 to 69.91 ± 6.64 per cent. The Los Baños covered tips, however, produced filled tips in treatments (*c*) and (*d*) but less than one per cent, the range being 0.6 ± 0.40 to 1.28 ± 0.86 per cent and the range of exposed tips, 54.27 ± 3.82 to 72.51 ± 2.82 per cent. In the Abra covered, the production of filled tips ranged from 2.24 ± 1.64 to 13.29 ± 0.15 per cent, and the exposed tips, 25.59 ± 5.53 to 35.09 ± 0.22 per cent. For Abra exposed the range was 2.22 ± .45 to 8.02 ± 2.85 for filled and 26.96 ± 6.17 to 38.43 ± 4.67 per cent for exposed tips.

In the wet-season culture the range of production of filled tips was from 40.15 ± 2.90 to 53.02 ± 4.44 per cent and for exposed tips 26.32 ± 3.16 to 56.00 ± 7.06 per cent for Abra covered. For Los Baños covered the range was 30.94 ± 4.63 to 30.94 ± 4.63 per cent for filled and 40.27 ± 3.86 to 61.29 ± 2.93 per cent exposed. For Los Baños exposed the range was 3.75 ± .83 per cent for filled and 7.14 ± 1.46 per cent for exposed. As a consequence, therefore, the percentage of nubbins in the wet-season culture was decreased.

It is interesting to note, however, that there was a higher percentage of filled tips in the Abra strain than in the Los Baños strain. The difference may be due to varietal characteristics of the two types of corn, of which the filled and exposed tips may be considered secondary characters.

There is no apparent difference, however, in the production of filled and exposed tips in the two strains, irrespective of the type of planting material in the lots, whether detasseled and hand-pollinated; with tassel and hand-pollinated; detasseled; or control.

SUMMARY AND CONCLUSIONS

In the present experiments attempts were made to determine agronomically and statistically the effects of pollination on the production of well-filled and non-filled ears of corn. The results thus obtained may be summarized as follows:

1. The two Native Yellow Flint corn strains which are referred to in these studies as Los Baños strain and Abra strain differ in ear types as well as in agronomic and cultural behavior of the plants. The Abra strain ears are shorter and have a thicker cob than the

Los Baños strain. In the wet season the average number of days to maturity of Abra strain was 87 days from date of sowing; in the dry season, 92 days. In the wet season the average number of days to maturity of Los Baños strain was 108 days from date of sowing; and in dry season, 116 days.

2. Two kinds of seed materials were used from each of the strains. These were the covered or well-filled ears and the partly-filled ears or those with exposed or bare cob tips. On an average, the well-filled ears gave a higher shelling percentage than the partly filled ears.

3. The studies were planned on the principle that sufficient pollination followed by perfect fertilization on the silk of each ear would result in formation of well-filled ears. Different degrees, therefore, of pollination were tested as follows: (*a*) plants detasseled, no treatment—the lot depended on natural agencies of pollination; (*b*) plants left with tassel, hand-pollinated—the pollen for this lot will be supplied from natural agencies of pollination, that is, pollen coming from their own tassels and from neighboring plants and pollen to be supplied artificially; (*c*) plants detasseled, and hand-pollinated; this lot will depend on pollen from plants of neighboring rows as well as on pollen applied artificially; (*d*) plants given no treatment; this lot will depend mostly on natural agencies of pollination. Of these lots treatment (*b*) received the greatest amount of pollen grains to be utilized for fertilization, followed by treatment (*c*) which was detasseled, hand pollinated. Treatment (*a*) received the least supply of pollen. Treatment (*d*) served as control representing the conditions in an ordinary corn field.

4. There was no significant effect in the production of covered and exposed tips for either strain grown in both wet and dry seasons, except in the case of Abra strain with covered tips grown in dry season where there was an increased production of filled ears in plots that received an artificial supply of pollen.

5. In all treatments for both strains, there was a greater increase in production of filled and exposed tips in the wet season than in the dry season, with a corresponding decrease in the production of nubbins.

6. The ratio of filled and non-filled portions was significant in favor of the control, proving that the length of the exposed portion of the ears was decreased in lots which received an additional supply of pollen grains in the dry season. In the wet-season culture there was no significant difference.

7. In general, the covered and exposed ears as planting materials, produced a slightly higher percentage of filled ears than non-filled ones. The seed from non-filled ears produced higher percentage of exposed tips than the covered ones. The difference, however, between covered and exposed tips was not statistically significant.

8. Supplementary pollination affected in some degree the length of bare cob tips in dry season culture and to a small extent in the wet season.

9. The results obtained from these experiments corroborate the conclusions of other workers to the effect that there was no significant difference between corn ears from well-filled tips and those from exposed tips.

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TABLE 1a

Showing mean percentages of exposed and filled tips and nubbins of Abra strain with covered tips in both seasons of planting

Wet Season

TREATMENT	EXPOSED TIPS		FILLED TIPS		NUBBINS	
	Mean	Difference	Mean	Difference	Mean	Difference
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Detasseled, hand pollinated						
Treated	39.49 ± 3.336		53.02 ± 4.4497		8.57 ± 2.4403	
Control	30.43 ± 2.755	9.06 ± 4.326	52.04 ± 5.2534	.98 ± 6.8818	10.43 ± 3.5122	1.36 ± 4.276
With tassel, hand pollinated						
Treated	26.32 ± 3.1679		49.04 ± 4.6779		20.54 ± 4.100	
Control	40.67 ± 4.3059	14.25 ± 5.3498	40.64 ± 5.6019	8.40 ± 7.2979	17.44 ± 3.2552	3.10 ± 5.1316
Detasseled, no treatment						
Treated	46.60 ± 2.4473		40.15 ± 2.9095		11.89 ± 2.2505	
Control	56.00 ± 7.0688	9.40 ± 7.4819	45.80 ± 7.26436	5.15 ± 7.8211	17.35 ± 2.3944	5.46 ± 3.2817
Dry Season						
Detasseled, hand pollinated						
Treated	25.59 ± 5.5375		13.29 ± .1519		53.38 ± 1.1601	
Control	35.09 ± 1.2208	9.50 ± 5.6727	3.50 ± .9578	9.79 ± .9616	60.54 ± 2.6036	7.16 ± 2.846
With tassel, hand pollinated						
Treated	33.18 ± 1.4839		13.2 ± 2.1449		54.32 ± 5.0990	
Control	35.09 ± 1.2208	1.91 ± 1.2288	3.50 ± 0.9578	9.70 ± 2.345	60.54 ± 2.6036	6.22 ± 5.7245
Detasseled, no treatment						
Treated	26.07 ± 1.123		2.24 ± 1.6458		70.87 ± .0742	
Control	35.09 ± 1.2208	9.025 ± 1.655	3.50 ± 0.9578	1.06 ± 1.9078	60.54 ± 2.6036	10.33 ± 2.6000

TABLE 1b

Showing mean percentages of exposed and filled tips and nubbins of Abra strain with exposed tips in both seasons of planting

Wet Season

TREATMENT	EXPOSED TIPS		FILLED TIPS		NUBBINS	
	Mean	Difference	Mean	Difference	Mean	Difference
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Detasseled, no treatment						
Treated	55.35 ± 4.3734		40.10 ± 3.5105		1.29 ± 1.2926	
Control	55.27 ± 5.0857	.12 ± 6.7082	45.00 ± 7.2330	4.90 ± 8.0411	3.06 ± .8897	1.87 ± 1.5684
With tassel, hand pollinated						
Treated	48.55 ± 5.0986		43.35 ± 3.7317		8.69 ± 2.6903	
Control	40.27 ± 3.8652	8.28 ± 6.3961	39.94 ± 4.2256	3.41 ± 5.6400	9.05 ± 2.706	.56 ± 3.8182
Detasseled, hand pollinated						
Treated	61.29 ± 2.9392		30.94 ± 4.6383		7.87 ± 5.0416	
Control	49.77 ± 3.8866	12.48 ± 4.8690	46.05 ± 4.7765	15.11 ± 6.661	7.24 ± 5.3630	.63 ± 7.3573

Dry Season

TREATMENT	EXPOSED TIPS		FILLED TIPS		NUBBINS	
	Mean	Difference	Mean	Difference	Mean	Difference
Detasseled, no treatment						
Treated	26.96 ± 6.1750		2.08 ± .3372		70.73 ± 6.8005	
Control	36.92 ± 1.7232	9.96 ± 6.4148	2.22 ± .4587	.14 ± .6096	56.34 ± 5.6253	14.39 ± 8.8352
With tassel, hand pollinated						
Treated	38.43 ± 4.6743		8.02 ± 2.8565		53.52 ± 1.6760	
Control	36.52 ± 1.7223	1.91 ± 4.9769	2.22 ± 0.4587	5.80 ± 2.8963	56.34 ± 5.6253	2.82 ± 5.8754
Detasseled, hand pollinated						
Treated	31.42 ± 1.7233		5.175 ± 2.0471		63.46 ± 2.9678	
Control	36.51 ± 1.7223	5.09 ± 2.4331	2.22 ± 0.4587	2.96 ± 2.1000	56.34 ± 5.6253	7.12 ± 6.3561

TABLE 1c

Showing mean percentages of exposed and filled tips and nubbins of Los Baños strain with exposed tips in both seasons of planting

Wet Season

TREATMENT	EXPOSED TIPS		FILLED TIPS		NUBBINS	
	Mean	Difference	Mean	Difference	Mean	Difference
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Detasseled, hand pollinated						
Treated	89.45 ± 2.8241		3.89 ± .8580		6.69 ± 1.1144	
Control	83.82 ± 1.4052	5.63 ± 3.1528	7.14 ± 1.4668	3.25 ± 1.7029	10.83 ± 1.6147	4.14 ± 1.9545
With tassel, hand pollinated						
Treated	85.64 ± 1.5292		6.52 ± 1.0384		8.00 ± 1.3839	
Control	87.46 ± 1.3839	1.82 ± 2.0590	4.73 ± .9610	1.79 ± .1414	5.21 ± 2.2512	2.79 ± 2.6400
Detasseled, no treatment						
Treated	81.92 ± 1.0932		6.36 ± 4.0238		10.46 ± 1.5379	
Control	86.27 ± 2.1383	4.35 ± 2.4020	3.75 ± .8315	3.11 ± 4.0049	10.47 ± 2.6597	.01 ± 3.0741

Dry Season

TREATMENT	EXPOSED TIPS		FILLED TIPS		NUBBINS	
Detasseled, hand pollinated						
Treated	38.98 ± 13.0104				35.33 ± 2.5766	
Control	58.41 ± 1.7166	19.43 ± 13.9300	—	—	41.27 ± 1.7672	5.94 ± 3.1272
With tassel, hand pollinated						
Treated	69.91 ± 6.6404				31.01 ± 8.1680	
Control	58.41 ± 1.71660	11.50 ± 6.8593	—	—	41.27 ± 1.7672	10.26 ± 8.3590
Detasseled, no treatment						
Treated	50.03 ± 18.9163				48.74 ± 19.5605	
Control	58.41 ± 1.7166	7.58 ± 19.0000	—	—	41.27 ± 1.7678	7.47 ± 19.6467

TABLE 1d

Showing mean percentages of exposed and filled tips and nubbins of Los Baños strain with covered tips in both seasons of planting

Wet Season

TREATMENT	EXPOSED TIPS		FILLED TIPS		NUBBINS	
	Mean	Difference	Mean	Difference	Mean	Difference
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Detasseled, hand pollinated						
Treated	76.52 ± 2.2623		18.55 ± 1.8595		6.43 ± 2,4534	
Control	70.19 ± 3.7875	5.33 ± 4.3125	23.69 ± 3.0976	6.14 ± 3.6152	5.96 ± 1.7833	.47 ± 3,0280
With tassel, hand pollinated						
Treated	75.40 ± 1.9619		15 36 ± 1.9849		10.93 ± 1.7233	
Control	79.15 ± 1.4977	3.75 ± 4.0112	15.13 ± 1.3183	.23 ± 2.3790	6.16 ± 1.1486	4.77 ± 1.9390
Detasseled, no treatment						
Treated	75.60 ± 2.4599		16.35 ± 2.3173		4.85 ± .6145	
Control	74.28 ± 1.5761	1.32 ± 2.9240	21.69 ± 1.6550	5.34 ± 2.3460	4.42 ± 1.2216	.43 ± 1.3638
Dry Season						
Detasseled, hand pollinated						
Treated	60.08 ± 5.2341		1.28 ± .8634		41.60 ± 1.6997	
Control	58.83 ± 7.2048	1.25 ± 8.8980	.70 ± .4687	.58 ± 1.0296	40.28 ± 7.4768	1.32 ± 7.6707
With tassel, hand pollinated						
Treated	72.51 ± 2.8261		—		32.89 ± 7.2778	
Control	58.83 ± 7.2048	13.68 ± 7.7363	—	—	40.88 ± 7.4768	7.38 ± 10.3920
Detasseled, no treatment						
Treated	54.27 ± 3.8244		.6 ± .4047		45.19 ± 3.5108	
Control	58.83 ± 7.2048	4.55 ± 8.1505	.70 ± .4688	.10 ± .6172	40.28 ± 7.4768	4.92 ± 8.2583

TABLE 2a

Showing the relation of exposed cob to filled portion of the ear in Abra Strain

TREATMENT	DRY SEASON				WET SEASON			
	Abra covered		Abra exposed		Abra covered		Abra exposed	
	Mean	Difference	Mean	Difference	Mean	Difference	Mean	Difference
	cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
Detasseled, hand pollinated								
Treated	1.095±.0034		1.115±.0236		1.10±.0135		1.14±.0119	
Control	1.160±.0208	.065±.0205	1.195±.0101	.08 ±.0257	1.08±.0117	.02±.0202	1.07±.0674	.07±.0684
With tassel, hand pollinated								
Treated	1.055±.0034		1.095±.0169		1.12±.0202		1.07±.0674	
Control	1.160±.0202	.105±.0205	1.195±.0101	.10 ±.0197	1.11±.0151	.01±.0202	1.08±.0674	.01±.0953
Detasseled, no treatment								
Treated	1.130±.0331		1.205±.0169		1.16±.0165		1.11±.0119	
Control	1.160±.0202	.03 ±.0202	1.195±.0101	.010±.0197	1.13±.0151	.01±.0252	1.10±.0095	.01±.0152

TABLE 2b

Showing the relation of exposed cob to filled portion of the ear in Los Baños Strain

TREATMENT	DRY SEASON				WET SEASON			
	Los Baños covered		Los Baños exposed		Los Baños covered		Los Baños exposed	
	Mean	Difference	Mean	Difference	Mean	Difference	Mean	Difference
	cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
Detasseled, hand pollinated								
Treated	1.195±.0169		1.24 ±.0202		1.14±.0095		1.22±.0117	
Control	1.200±.0000	.005±.0169	1.30 ±.0067	.06 ±.0066	1.11±.0095	.03±.0135	1.21±.0165	.01±.0202
With tassel, hand pollinated								
Treated	1.200±.0067		1.195±.0034		1.21±.0596		1.20±.0674	
Control	1.200±.0000	—	1.30 ±.0067	.105±.0074	1.13±.0095	.08±.0604	1.23±.0135	.03±.0687
Detasseled, no treatment								
Treated	1.230±.0067		1.30 ±.0135		1.13±.0151		1.21±.0135	
Control	1.200±.0000	.030±.0066	1.30 ±.0067	—	1.13±.0674	—	1.26±.0320	.05±.0347

A COMPARATIVE STUDY OF THE CHICKS OF FIVE DIFFERENT BREEDS OF POULTRY[1]

F. M. FRONDA AND BONIFACIO T. YÑIGUEZ

A number of improved breeds of chickens is now available in the Philippines, hence prospective poultry raisers are often confronted with the problem of which breed to choose. Since success in poultry raising depends to a great extent upon the chicks' ability to grow, it is, therefore, timely that definite data bearing upon the performance of the chicks of these different breeds of chickens be known, so that poultry raisers may have a guide in choosing the breed that will give the best results under a given set of Philippine conditions.

This experiment was conducted with the following objects: (1) to compare the incubation results of the Los Baños Cantonese, Nagoya, S. C. Rhode Island Red, S. C. White Leghorn, and Mikawa eggs; (2) to compare the rate of growth of the chicks hatched from these eggs, and; (3) to determine the percentages of mortality of the growing stock. It was begun in December, 1932 and was carried continuously to August, 1934, thus covering a period of 18 months.

REVIEW OF LITERATURE

Commenting on imported standard breeds of chickens in the Islands, Gonzalez (1926) reported that the Rhode Island Red, the Barred Plymouth Rock and the White Leghorn from the United States and Australia had been introduced in the Islands in the largest numbers. He further said that none of these breeds had proved to be adapted to Philippine conditions. He stated also that, "it has been possible to maintain the improved stock alive so long as they were not exposed to infectious diseases as fowl cholera and chicken pox, but they were poor layers. It proved very difficult to raise a second generation of pure breeds. The few that have been

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[1] The data presented in this paper were taken from the thesis presented by the junior author for graduation, 1934, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 496; Experiment Station contribution No. 1116. The thesis was prepared under the direction of Dr. F. M. Fronda.

Received for publication June 20, 1935.

raised were stunted, unthrifty and otherwise unsatisfactory, due in no small measure to intestinal parasites, such as round and flat worms."

Fronda (1932) stated that Eurpoean breeds as the Leghorn, and American breeds as the Plymouth Rock and Rhode Island Red are becoming adapted to the Philippines with much difficulty. To quote this author, "The College has succeeded in only just about keeping these breeds going. The difficulties that have been met with them have been relatively serious. Because of these difficulties it has not been possible to improve the breeds. At present the specimens in the College have deteriorated in size and egg production when compared with their records in their homelands."

Regarding the Cantonese chicken, Fronda (1924) reported that, unlike other breeds, the Cantonese responds very favorably to local environmental conditions and the native methods of feeding, care, and management. He further stated that the birds are active and are very hardy, remaining healthy under conditions in which all the other imported breeds do not thrive. An early experiment comparing the rate of growth of Cantonese with other breeds of poultry showed that the average weight of the Cantonese at the age of 12 weeks was 317.28 grams (Lindayag, 1918). A recent study on the rate of growth of the Los Baños Cantonese chicken showed that at the age of 12 weeks the birds attained an average of 460.1 grams Tioaquen, 1933).

The Nagoya fowl was introduced into the Islands from Japan in 1926 (Fronda and Gonzalez, 1929). Shinji (1927) reported that it was selected and improved from a cross of native farm fowls and Shanghais which were imported from South China in the latter part of the nineteenth century. He also stated that the chickens make good broilers at two months old; the surplus cockerels may be fattened and sold as good roasters at four months of age. The Nagoya breed is now almost as much at home in the Philippines as the Los Baños Cantonese. Perhaps the reason for this, as stated by breed carries some blood of our popular Cantonese breed. Tioaquen Fronda and Gonzalez (1929), is that it is very probable that this (1933) observed that the Nagoya chickens, at the age of 12 weeks, attained an average weight of 514.6 grams.

The S. C. Rhode Island Red can now be found in many places in this country. Morgan (1928) stated that under American conditions the American breeds are best adapted for farm flocks where both eggs and meat are desired. Kaupp (1921-1922) reported that, in the United States, the S. C. Rhode Island Red attains, at the age of 12 weeks, an average of 2.14 lb. (972.7 grams). Mendoza (1925) determined the rate of growth of Rhode Island Red and observed that, at 12 weeks old, the average weight of the males was only 551.0 grams, and the females, 443.3 grams.

The S. C. White Leghorn is also well known to local poultry raisers. Kaupp (1922) studied the rate of growth of the S. C. White Leghorn and found that the birds weighed 1.24 lb. (563.6 grams) at the age of 12 weeks. A recent study on the rate of growth of S. C. White Leghorn chicks by Tamayo (1934) showed that the average weight of these chickens at the age of 12 weeks was 490.7 grams.

The Mikawa is a new breed recently introduced into the Islands from Japan. No study on the rate of growth of the bird has as yet been reported in the Philippines. In a report of the Imperial Zootechnical Experiment Station of Japan in 1927 (Anonymous, 1927), it is claimed that the Mikawas are very good layers. Yoshio (1930) described the Mikawa breed as follows: "this is a cross-breed of the Nagoya with the Buff Plymouth Rock and other breeds. It is lighter than the Nagoya and might be regarded as an egg-laying breed." Fronda (1931) in a summary of the First Philippine Egg Laying Contest, reported that from the standpoint of income from the sale of eggs, the Mikawa fowls topped the list of contestants which included Los Baños Cantonese, Nagoyas, Rhode Island Reds, and S. C. White Leghorns.

PLAN OF THE STUDY

Eggs used. Selected eggs of the Los Baños Cantonese, Nagoya, S. C. Rhode Island Red, S. C. White Leghorn, and Mikawa breeds of fowls were used in this experiment. Eggs for each setting were collected for ten days. The same number of eggs from each breed was used in the first six hatches. This plan, however, could not be followed in the last four hatches, as the eggs of some of the breeds studied became very limited. To offset this difficulty, all the available hatchable eggs for each breed were collected and used for incubation. These eggs were artificially hatched in the same incubator. In all, there were ten hatches made in which a total of 358 eggs for the Los Baños Cantonese, 342 eggs for the Nagoya, 367 for the S. C. Rhode Island Red, 356 for the S. C. White Leghorn, and 326 for the Mikawa were used.

The eggs were weighed before they were placed in the incubator. Each infertile egg was verified to be so by breaking it into a saucer and the germ examined. To facilitate marking of the chicks of the different breeds, each egg was put in a cloth bag on the eighteenth day of incubation.

Brooding and care of the chicks. Twenty-four hours after hatching, the chicks were leg-banded, and placed in the brooding quarters. An all-mash ration composed of 25 parts, by weight, of shrimp meal, 56.25 parts rice bran, and 18.75 parts corn meal (3:1) was given to the chicks. This feed was placed in mash hoppers that were kept open to the birds throughout the day. Bamboo drinking troughs were provided, and a supply of fresh water was kept in them throughout the day.

Records kept. The chicks were weighed 24 hours after hatching and every week thereafter, till they were 12 weeks old. These weights were carefully recorded. Weighing was done on a Cenco balance, sensitive to a tenth of a gram. Records of deaths were also kept.

RESULTS AND DISCUSSION

Incubation. Table 1 shows the incubation records of the eggs of the five breeds studied. This table includes the means of the percentages of infertility, the embryonic mortality, and the hatchability of the eggs hatched in the ten trials made.

It may be seen by referring to table 1 that the percentage of infertile eggs in all breeds studied varied from 20.30 among the Nagoya eggs to 33.98 among the Mikawas. The Los Baños Cantonese with infertility of 32.23 per cent, was second to the Mikawa, the difference between the two being only 1.75 per cent. These two breeds, therefore, may be ranked as least fertile. The fertility of the Nagoya eggs was the highest, this was followed by the S. C. Rhode Island Reds, and then by the S. C. White Leghorns. The difference between the Nagoya and the S. C. Rhode Island Red was, however, only 3.17 per cent and that between the S. C. Rhode Island Red and the S. C. White Leghorn was 3.43 per cent.

Martir (1933) reported an infertility of 10.7 per cent for the Nagoya eggs and 28.2 per cent for the Los Baños Cantonese. The results obtained in the present work, although somewhat poorer than those reported by Martir, nevertheless, are in agreement with Martir's figures in that the Nagoya eggs are more fertile than the Los Baños Cantonese eggs. Tamayo (1934) obtained 25.7 per cent infertile eggs for the standard S. C. White Leghorn. The percentage obtained in this study for the same breed was 26.9 per cent, the difference being only 1.2 per cent.

Embryonic mortality. By reference also to table 1 it may be seen that the Los Baños Cantonese had the lowest percentage of embryonic mortality, 25.37 per cent, the S. C. Rhode Island Red, 36.19 per cent, and the Nagoya, 36.24 per cent, followed. The S. C. White Leghorn was fourth with 38.60 per cent, and the Mikawa had the highest percentage of embryonic mortality, with 39.82 per cent. The difference between the Los Baños Cantonese and the other breeds studied was statistically significant, the Los Baños Cantonese having the lowest embryonic mortality. The differences between the Nagoyas and both the S. C. White Leghorns, and the S. C. Rhode Island Reds were significant. Comparing the Nagoyas and the Mikawas, the difference was significant in favor of the former. The S. C. Rhode Island Red showed an insignificant difference when compared with the S. C. White Leghorns; but when it was compared with the Mikawas, the difference was significant. The S. C. White Leghorns when compared with the Mikawas showed an insignificant difference.

Ordoveza (1927) reported 38.43 per cent of embryonic mortality from Los Baños Cantonese eggs hatched in December; 44.06 per cent from those hatched in February; and 43.01 per cent for those hatched in April. Tamayo (1934) reported an average of 37.4 per cent embryonic mortality for the S. C. White Leghorns. Martir (1933) found that the percentage of embryonic mortality of the Nagoya eggs was 41.8 per cent and that of the Los Baños Cantonese, 35.8 percent. It appears, therefore, that the relationship of results obtained in this study was similar to those reported by previous workers.

Eggs hatched from all eggs incubated. The average percentage of hatch of the five breeds was rather low when based on the total number of eggs set, as may be seen by referring to table 1. It may be seen that, in spite of the high infertility of the Los Baños Cantonese eggs, the percentages of hatch based on the total number of eggs set did not vary greatly when compared with the Nagoyas, and the S. C. Rhode Island Reds. The Mikawas had the lowest hatching percentage, with a mean of only 26.20 per cent. This was followed by the S. C. White Leghorn with 34.51 per cent. Martir (1933) reported that the Nagoya eggs hatched better than the Los

Baños Cantonse eggs. Tamayo (1934) found that the average percentage of hatch of the S. C. White Leghorn was 36.9 per cent.

Weights of eggs and chicks. Table 2 shows the comparative weights of the eggs and the day-old chicks of the different breeds studied. These figures were based only on the last four hatches. From this table it may be seen that the Los Baños Cantonese eggs were the lightest, and as expected, the weight of the chicks was also the lightest. The ratio between weight of chicks to weight of egg, however, was the highest, being 68.35 per cent. The S. C. Rhode Island Red eggs were the heaviest and consequently the chicks were also the heaviest, but the chick-egg ratio was only 65.11 per cent. It may be seen that both the eggs and the newly hatched chicks of the S. C. White Leghorn and the Mikawa breeds weighed almost the same. The S. C. White Leghorn chicks were 62.84 per cent of the weight of the eggs, and the Mikawas, 63.39 per cent. The eggs of the Nagoyas had a mean weight of 48.5 grams, and the chicks was 65.91 per cent of that of the eggs. The Los Baños Cantonese chicks, therefore, stood first among the five breeds in the ratio of the percentage of their weights to the weights of their respective eggs. This superiority may have been because the chicks were more vigorous, or it may also be because the shells of the Los Baños Cantonese eggs were comparatively thinner than those of the eggs of the other four breeds.

Growth of chicks. Table 3 shows the rate of growth of the five breeds studied. From this table it may be seen that the S. C. Rhode Red chicks were the heaviest, with the Nagoyas, second, followed by the Mikawas, the S. C. White Leghorns, and the Los Baños Cantonese in the order named. When treated statistically, the S. C. Rhode Island Red chicks were found to be significantly heavier than any of the chicks of the other breeds studied.

Regarding the weight of day-old Cantonese chicks, previous workers reported the following: Lindayag (1918), 26.5 grams; Resananda (1924), 29.7 grams; Mendoza (1925), 28.3 grams; Dañgilan (1926), 28.6 grams; Ordoveza (1927), 27.6 grams for those hatched in December, 25.4 grams for those hatched in February, and 19.4 grams for those hatched in April; Tioaquen (1913), 24.7 grams; and Martir (1933), 27.6 grams. It may be noted that the initial weight of 28.8 grams obtained in this study was a little lighter than the chicks studied by Resananda (1924) but heavier than those reported by the other workers.

Concerning the weight of Nagoya chicks, Tioaquen (1933) reported 28.2 grams and Martir (1933), 30.1 grams; thus the mean weights obtained in the present work, 31.9 grams, was slightly heavier than those reported by the previous workers. Previous workers who made observations of weights of day-old Rhode Island Red chicks, reported the following: Mendoza (1925), 31.3 grams and Resananda (1924), 34.6 grams. Under conditions obtaining in the United States, Warren (1930) reported that the average weight of S. C. Rhode Island Red chicks at hatch was 34.5 grams for the females and 34.5 grams for the males. The initial weight of 33.5 grams as obtained in this study was only slightly lighter than those reported by Resananda (1924) and Warren (1930), but heavier than that reported by Mendoza (1925).

It may also be noted that the findings of previous workers on the average initial weight of S. C. White Leghorn chicks were not materially different from that obtained in the present study. Resananda (1924) reported 29.5 grams as the average weight of his day-old chicks. Warren (1930) obtained an average of 31.9 grams for the male and 32.2 grams for the female S. C. White Leghorn chicks. Tamayo's (1934) chicks averaged 32.6 grams at the age of one day. In this study the weight of the day-old S. C. White Leghorn chicks was 30.8 grams. This weight was, therefore, slightly heavier than that obtained by Resananda (1924) and comparatively lighter than those reported by the two later workers.

By referring again to table 3, it may be noted that the initial weights of all the breeds studied were more than doubled by the time that the chicks were four weeks old. The S. C. Rhode Island Red chicks had the heaviest mean weight; the Mikawas, second; the S. C. White Leghorns, third; and the Nagoyas, fourth. The Los Baños Cantonese chicks were the lightest. At the age of 8 weeks the Nagoya chicks were the heaviest of the lot; the Mikawas, second; the S. C. Rhode Island Reds, third; the Los Baños Cantonese, fourth; and the S. C. White Leghorn chicks which were the third heaviest during the fourth week, last. This relationship in size was maintained up to the time all the chicks of the five breeds were 12 weeks of age. At this age the Nagoyas were the heaviest and the S. C. White Leghorns were the lightest of the five breeds studied.

Lindayag (1918) reported 317.28 grams as the average weight of his 12 week-old Cantonese chickens; Mendoza (1925), 485.00 grams; Dañgilan (1926), 308.9 grams; and Tioaquen (1933), 460.1 grams. As may be seen in table 3, the mean weight of the

Los Baños Cantonese chicks at the same age as observed in this study was 486.4 grams. This is heavier than the weights reported by the workers named above, except that reported by Mendoza (1925).

Tioaquen (1933) reported an average of 514.6 grams as the weight of Nagoya chicks at 12 weeks of age; Kaupp (1922), 2.14 lb., or 972.7 grams for the S. C. Rhode Island Red and 1.24 lb. or 563.6 grams for his S. C. White Leghorn chicks; Mendoza (1925), 497.1 grams for Rhode Island chicks; Warren (1930), 1007.9 grams for female S .C. Rhode Island Red chicks, 849.4 grams for female S. C. White Leghorns; and Tamayo (1934), 490.7 grams for S. C. White Leghorn chicks. It may be seen, therefore, that at the age of 12 weeks, the weights of the Los Baños Cantonese, 486.4 grams; Nagoya, 529.9 grams; S. C. Rhode Island Red, 528.1 grams; Mikawa, 488.0 grams; and S. C. White Leghorn chicks, 468.8 grams, in this study compared favorably with those reported by previous workers in this country, but those of S. C. Rhode Island Red and S. C. White Leghorn chicks were much lower than those reported by the workers in the United States.

Comparative rates of growth. In the determination of the percentage rate of growth of the chicks of the different breeds studied the following formula, as suggested by Brody (1927) was used:

$$R = \frac{(W_2 - W_1)100}{\frac{1}{2}(W_2 + W_1)}$$

In this formula, W_1 represents the original weight of the bird and W_2, the final weight. Brody has shown statistically, that this formula takes into account the instantaneous compoundings that take place in a natural growth process. When applied to the figures given in table 3 a very interesting result was noted (table 4).

By reference to table 4, it may be seen that during the first four weeks of age, all of the chicks grew at almost the same rate, with the S. C. White Leghorns slightly leading the rest. From four to eight weeks, however, the Los Baños Cantonese and the Nagoya chicks maintained their rate of growth while the rest dropped, this time the S. C. White Leghorns had the poorest rate. From the eighth to the twelfth week of age, the chicks all dropped in their rate of growth. This drop in the rate of growth of the chicks at this age was expected, as the chicks were then older and the period of most rapid growth already passed. At this age, the S. C. Rhode Island Red chicks lead the other breeds in the rate of growth.

Computing the percentage rate of growth of the chicks from hatch to twelve weeks of age, it is interesting to note that there is a tendency for both the Los Baños Cantonese and Nagoya to lead, the S. C. Rhode Island Red following, and both the S. C. White Leghorn and Mikawa chicks, the last. These results confirm the observations that both the Los Baños Cantonese and Nagoya breeds of fowls seem to be more at home in this country than any other introduced breeds of poultry (Fronda, 1924); Fronda and Gonzalez, 1929).

Mortality. Table 5 gives the percentages of mortality of the chicks of the five breeds. It may be noted that the percentages of mortality of all the chicks of all breeds studied were rather high. This may be because all these breeds were confined in one lot. Once a bird was infected, especially by roup, the chicks that were less susceptible readily succumbed, while those that were more resistant were also infected in the long run. It is very probable that had the different breeds been raised separately, the mortality of each breed would have been considerably lowered. Furthermore, some of the hatches were made during the "off seasons," and for this reason, the chicks were exposed to rather unfavorable brooding conditions.

The results obtained under the conditions in which these studies were made showed that the Los Baños Cantonese chicks had the least mortality with 47.94 ± 5.386 per cent, and the S. C. White Leghorn had the most mortality with 55.10 ± 5.303 per cent. Although there were no significant differences in the mortality figures obtained, there seems to be a tendency for the Los Baños Cantonese and the Nagoya chicks to be less susceptible to unfavorable brooding conditions than the chicks of the other breeds studied. Observations made in this study showed that the mortality of the chicks was largely caused by roup. The S. C. White Leghorn chicks were observed to be the most susceptible to this disease. The Los Baños Cantonese chicks proved to be very resistant and was the last group to be infected.

Some practical applications. A number of practical applications of these findings should be noted. If a poultryman should desire to produce 100 baby chicks, how many eggs should he place in the incubator? Or if he intends to have 100 weanlings, how many eggs must he incubate or how many baby chicks must he provide at the start? Basing from the results of these findings, the figures obtained may be seen on table 6.

By reference to table 6, it may be seen that, basing calculations on the percentage of all eggs set, to produce 100 baby chicks it would require the following: Nagoya, 230; Los Baños Cantonese, 236; S. C. Rhode Island Red, 248; S. C. White Leghorn, 290; and Mikawa, 382. To produce 100 weanlings, that is, chicks at the age of 12 weeks of age, of the different breeds studied, 453 eggs of the Los Baños Cantonese, 458 of the Nagoya, 533 of the S. C. Rhode Island Red, 646 of the S. C. White Leghorn, and 847 eggs of the Mikawa will be needed for incubation. Basing judgment on the hatchability of the eggs, the rate of growth and the ability of the chicks to survive, the five breeds studied may be ranked as follows: (1) Los Baños Cantonese, (2) Nagoya, (3) S. C. Rhode Island Red, (4) Mikawa, and (5) S. C. White Leghorn. The last two breeds ranked about the same.

SUMMARY AND CONCLUSIONS

The results obtained in this study may be summarized as follows:

1. The Nagoya eggs had the highest percentage of fertility and the Mikawa eggs, the lowest.

2. The highest percentage of embryonic mortality was observed among the Mikawa eggs, and the lowest, among the Los Baños Cantonese eggs.

3. Computing the percentage of hatchability, based on the total eggs set, the Nagoya eggs had the highest, the Los Baños Cantonese, second; the S. C. Rhode Island Red, third; the S. C. White Leghorn, fourth; and the Mikawa, fifth.

4. In proportion of weight of chicks to the weight of the respective eggs, the Los Baños Cantonese stood first, and the S. C. White Leghorn stood last.

5. At the age of one day, the S. C. Rhode Island Red chicks were the heaviest; the Nagoyas, second; the Mikawas, third; the S. C. White Leghorns, fourth; and the Los Baños Cantonese, the lightest.

6. The average initial weight of the chicks of all breeds was more than doubled by the fourth week.

7. At the age of 12 weeks, the Nagoya and the S. C. Rhode Island Red chicks, which weighed about the same, were the heaviest, the Mikawas and the Los Baños Cantonese were second, and the S. C. White Leghorn chicks were the lightest.

8. Basing comparison on the percentage rate of growth of the chicks, no difference was observed between the different breeds during the first four weeks of age. From the fourth to the eighth

week, however, the Los Baños Cantonese and Nagoya chicks lead the rest.

9. In percentage rate of growth from the first to the twelfth week, a tendency was shown that the different breeds stood in the following order: Los Baños Cantonese, Nagoya, S. C. Rhode Island Red, S. C. White Leghorn and Mikawa.

10. The Los Baños Cantonese and the Nagoya chicks had the lowest percentage of mortality among the five breeds used in this study. The highest percentage of mortality occurred among the S. C. White Leghorns; the S. C. Rhode Island Reds and the Mikawas occupied intermediate positions.

11. Computed from the figures obtained in this study, the number of eggs required for incubation in order to produce 100 living chicks, is as follows: Nagoya, 230; Los Baños Cantonese, 236; S. C. Rhode Island Red. 248; S. C. White Leghorn, 290; and Mikawa, 382.

12. Computed from the figures obtained in this study, the number of eggs required for incubation in order to produce 100 weanlings is as follows: Los Baños Cantonese, 453; Nagoya, 459; S. C. Rhode Island Red, 533; S. C. White Leghorn, 646; and Mikawa, 847.

13. From these results, basing judgment on the hatchability of the eggs, rate of growth, and the capability of the chicks to survive, the five breeds studied may be ranked as follows: (1) Los Baños Cantonese, (2) Nagoya, (3) S. C. Rhode Island Red, (4) Mikawa, and (5) S. C. White Leghorn. The last two breeds ranked about the same.

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TABLE 1

Showing the incubation results of the five breeds of chickens studied (average of ten hatches)

ITEM	LOS BAÑOS CANTONESE		S. C. RHODE ISLAND RED	S. C. WHITE LEGHORN	MIKAWA
Number of eggs set	358	342	357	356	326
Percentage of infertiles	32.23	20.30	23.47	26.90	33.98
Percentage of embryonic mortality	25.37	36.24	36.19	38.60	39.82
Percentage of hatchability (of total eggs set.)	42.40	43.46	40.34	34.51	26.20

TABLE 2

Showing the comparative weights of the eggs and day-old chicks of the five breeds (average of four hatches)

BREED	WT. OF EGGS	WT. OF CHICKS	PER CENT WEIGHT
	grams	*grams*	*per cent*
Los Baños Cantonese	42.4	29.8	68.35
Nagoya	48.5	32.0	65.91
S. C. Rhode Island Red	52.1	33.9	65.11
S. C. White Leghorn	51.3	32.3	62.84
Mikawa	51.3	32.5	63.39

TABLE 3

Showing the rate of growth of the five breeds of chickens studied (average of ten hatches)

AGE	LOS BAÑOS CANTONESE		NAGOYA		S. C. RHODE ISLAND RED		S. C. WHITE LEGHORN		MIKAWA	
	Number	Weight	Number	Weight	Number	Weight	Number	Weight	Number	Weight
		grams		*grams*		*grams*		*grams*		*grams*
Day-old	138	28.8	141	31.9	143	33.5	132	30.8	91	31.7
4 weeks	98	85.3	93	92.7	92	97.2	77	93.1	54	93.9
8 weeks	81	247.9	73	269.0	76	248.1	66	228.8	37	250.4
12 weeks	80	486.4	68	529.9	64	528.1	60	468.8	34	488.0

TABLE 4

Showing the rate per cent of growth of the five breeds of chickens studied (average of ten hatches)

BREED	AGE IN WEEKS			
	1-4	4-8	8-12	1-12
	per cent	*per cent*	*per cent*	*per cent*
Los Baños Cantonese	98.26	97.60	64.97	177.64
Nagoya	97.59	97.51	65.31	177.29
S. C. Rhode Island Red	97.40	87.36	72.15	176.14
S. C. White Leghorn	100.65	84.34	68.81	175.62
Mikawa	99.04	89.84	64.36	175.57

TABLE 5

Showing the percentage of mortality of the chicks of the different breeds studied up to twelve weeks of age (average of ten hatches)

BREED	AVERAGE MORTALITY
Los Baños Cantonese	47.94 ± 5.386
Nagoya	49.87 ± 5.121
S. C. Rhode Island Red	53.54 ± 4.009
S. C. White Leghorn	55.10 ± 5.303
Mikawa	54.99 ± 5.084

TABLE 6

Showing the number of eggs that will be required to produce 100 baby chicks and 100 weanlings in each of the five breeds studied

BREED	TO PRODUCE 100 BABY CHICKS	TO PRODUCE 100 WEANLINGS	
		Number of eggs	Number of baby chicks
Los Baños Cantonese	236	453	192
Nagoya	230	458	199
S. C. Rhode Island Red	248	533	215
S. C. White Leghorn	290	646	223
Mikawa	382	847	222

COLLEGE AND ALUMNI NOTES

His Excellency, Manuel L. Quezon, president of the Philippine Commonwealth, honored the College of Agriculture with a visit on February 17. After visiting the grounds and laboratories and seeing the College at work, he spoke in the auditorium on the duties of citizenship under the new government. He was accompanied by President Jorge Bocobo, of the University of the Philippines.

In the twenty-sixth general commencement exercises of the University of the Philippines, held at Manila on March 31, the following College of Agriculture seniors were graduated. Their respective departments are indicated in parentheses.

Bachelor of Agriculture

1. Ambrosio P. Cacayan (soils)
2. Leandro R. Lopez (agronomy)
3. Panfilo B. Mañgahas (soils)
4. Guillermo A. Pangga (entomology)
5. Mariano S. Perlas, Jr. (agricultural engineering)
6. Ignacio J. Valentin (agricultural chemistry).

Bachelor of Science in Agriculture

1. Marcelo R. Abelardo (agronomy)
2. Melecio G. Agustin (agronomy)
3. Isaias A. Cabauatan (agronomy)
4. Alfonso A. Capili (agronomy)
5. Rufo D. Dacanay (agronomy)
6. Pedro G. Eamiguel (animal husbandry)
7. Benjamin O. Eleazar (animal husbandry)
8. Juan A. Galapon (agronomy)
9. Jesus D. Hemedes (agronomy)
10. Vicente G. Hicaro (agronomy)
11. Simeon N. Inumerable (agronomy)
12. Rasuman Macalandong (agronomy)
13. Bonifacio M. Manaligod (agronomy)
14. Esteban C. Nera (agricultural engineering)
15. Flaviano P. Olivares, Baker scholar, 1935-1936 (animal husbandry)
16. Inocencio V. Perez (agronomy)

17. Aquilino V. Platon (agronomy)
18. Ernesto L. Rigor (agricultural engineering)
19. Hector A. Rivera (agronomy)
20. Eufronio A. Rodriguez (animal husbandry)
21. Martiniano E. Rosell (plant physiology)
22. Alfredo A. Sabado (agronomy)
23. Roman B. Saladino (agronomy)
24. Felix N. Salcedo, Baker scholar, 1935-1936 (agronomy)
25. Demetrio S. Santos (agronomy)
26. Hilario J. Santos (agronomy)
27. Domingo C. Siapno (soils)
28. Martin V. Tiangco (agricultural chemistry)
29. Guillermo D. Valdez (animal husbandry)
30. Ignacio E. Villanueva (agricultural chemistry)

Bachelor of Science in Sugar Technology

1. José C. Atienza
2. José E. Borromeo
3. Francisco Rizal Lopez

Certificate in Agricultural Education

1. Acelo C. Badelles
2. Roman B. Saladino

As a response to the need of the times, a new extension course, entitled "Industrial utilization of farm products," to be given in summer by the Department of Agronomy, was added to the subjects available at the College of Agriculture. It is a practical course which carries no college credit and is designed to acquaint students with the art of manufacturing such products as soap from coconut oil, starch, flour and tapioca from cassava, soybean sauce, broom, articles from coconut coir, and sacks. Rudimentary principles of planting, cultivation and care of crops from which these commercial articles are obtained are likewise included.

Dean Edward R. Hyde, of the College of Engineering, University of the Philippines, was the commencement speaker at the graduation exercises of the U. P. Rural High School in the evening of March 28. Fourteen seniors received their diplomas. Mr. Augusto R. Mondoñedo, a son of Prof. Mariano Mondoñedo, of the Department of Animal Husbandry, was the valedictorian. Augusto was the second son of Doctor Mondoñedo to have attained this distinction in that school.

A surprise feature of the general faculty meeting of the College of Agriculture on March 24 was the part dedicated to two retiring members of the staff, Miss Emma S. Yule, head of the English Department, and Miss Anne F. Cole, assistant professor of English. An oil painting of the campus view from the east porch of the Copeland House, where Miss Yule lived for many years, was presented to her, and a photographic set of College scenes to Miss Cole. Both faculty members have stood high in the esteem of their colleagues, with whom they have worked for a long time, Miss Yule since January 1, 1915, and Miss Cole since June 8, 1928.

Four new members were initiated at the last public meeting of the Society for the Advancement of Research on March 19. These were Dr. Eulalio P. Baltazar, of the College of Agriculture, Dr. Patrocinio Valenzuela, of the College of Pharmacy, Dr. Amando Clemente, of the College of Liberal Arts, and Dr. Alfredo C. Santos, of the College of Pharmacy, University of the Philippines. In the program which followed, after the opening remarks by Dr. N. B. Mendiola, Dean B. M. Gonzalez, president of the Society introduced the guest of honor, Mr. Evett D. Hester, financial adviser to the U. S. High Commissioner, who read a paper entitled, "Caveat, scientists!"

The following new officers were elected for 1936-1937 at the meeting of the Society for the Advancement of Research on March 26: Dr. Miguel Manresa, president, Dr. F. M. Fronda, vice-president, Dr. José B. Juliano, secretary, and Dr. Leon G. Gonzalez, treasurer. In the evening of the same date, the Los Baños Biological Club met and elected its new officers as follows: Dr. Leon G. Gonzalez, president, and Mr. Emiliano F. Roldan, secretary.

At the last three 1936 monthly scientific meetings of the Los Baños Biological Club, the following papers were presented:

January 30

Dr. G. O. Ocfemia, Inocencio C. Manzo, and M. S. Celino: The gum disease of citrus in the Philippines. (Paper read by Mr. Celino).

Dr. Miguel Manresa and Dr. B. M. Gonzalez: Studies on surra, IV: Variability in size of trypanosomes, recovery and immunity from surra, natural and acquired. (Paper read by Dr. Manresa).

February 27

Mr. F. A. Soliven and Dr. A. I. de Leon: Extraction of coconut oil by bacterial process. (Paper read by Mr. Soliven).

Dr. Pablo N. Mabbun: Some problems connected with our future foreign trade.

March 26

Mr. Julian Banzon: On the measurement of velocity of reaction between coconut oil and ethyl alcohol.

Dr. L. B. Uichanco: Secular trends of locust outbreaks in the Philippines and their apparent relation with sunspot cycles.

ENROLLMENT AND EDUCATIONAL STANDARDS AT THE COLLEGE OF AGRICULTURE[1]

When the College of Agriculture was founded in 1909, a six-year curriculum, based on the completion of the intermediate grades, was instituted, alongside the regular collegiate four-year course, in response to a definite need. Agriculture in those days was not generally considered among our people as a profession, and certainly not one with which a father who could afford to invest in a college education would readily gamble the future of his son. In the meantime, extensive promotional activities aimed at reshaping Philippine agricultural industries along modern lines were being undertaken by the government. Soon followed, likewise, a rapid development of private agricultural enterprises, especially in connection with sugar production. All these ventures demanded for their varied projects technically prepared men. There were then in existence only two or three rare specimens of Filipino college graduates in agriculture; and these had their schooling as pensionados in the United States. Hence, the required personnel with proper qualifications had to be imported largely from abroad at considerable expense.

By slow degrees, the emergency which had called for heroic relief measures passed, owing to a succession of graduating classes in this college. The value of the six-year curriculum was reflected in the degrees granted, of which during the first ten years of the college 75 per cent were that of bachelor of agriculture, as distinguished from the standard degree of bachelor of science in agriculture. In part because of the advantage of a larger number, for a time bachelors of agriculture constituted the major source of recruits for technical agricultural service. Many of them eventually found themselves occupying pivotal positions. That not a few could acquit themselves creditably in scholarship, side by side with holders of any other kind of bachelor's degree, is borne out by those among them who went abroad. They were admitted to full graduate standing, leading to doctorates, in reputable American and European universities. However, the important thing is that, were it not for

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[1] General contribution from the College of Agriculture No. 527.

THE PHILIPPINE AGRICULTURIST, VOL. XXV, NO. 2, JUNE, 1936.

these bachelors of agriculture, who up to 1929 represented 58 per cent of our graduates, we might have continued to bewail the insufficiency of local technical agriculturists to meet the needs of the country.

For all the good it did during the earlier transitional period, the six-year curriculum manifestly added for each student an extra two-year drain on the resources of the college in preparatory instruction that could have been given more cheaply and perhaps more satisfactorily in secondary schools. Moreover, it was about twice as wasteful of student raw material as the four-year curriculum. While an average of 1 out of 3[a] students succeeded in graduating in the four-year curriculum, only an average of 1 out of 6[a] managed to complete the six-year.

It seems an act of poetic justice that a dean who was himself a bachelor of agriculture, together with a faculty 70 per cent of which consisted of individuals whose first degree was that of bachelor of agriculture, should have dealt the hand that stifled the six-year curriculum when it was beginning to outlive its usefulness and was, in its obsolescence, giving unhealthy signs of becoming "the tenth transmitter of some foolish face." There was naturally some premonition in withdrawing the course in 1929: that an altogether too serious a shrinkage in the student population would result. To be sure, there followed a progressive annual reduction in the size of the student body up to the academic year 1934-1935, when the dip in the figure to 426 represented the lowest in fifteen years. Of course, the prevailing financial depression, which affected attendance in almost all other educational institutions, was largely to blame. But the exclusion of intermediate graduates from the college proper also cut a major slice. However, these disadvantages were not without their compensation. The steadily mounting percentage of high school graduates in the student body has removed to a large extent disturbing obstacles to scholastic standards. As it is, even with the present reduced number of students, our ratio of students to teachers at the College of Agriculture (1935-1936) is 7:1. If we disregard the assistants, who, as apprentices, do no independent teaching, the ratio becomes 10:1. These ratios are rather high when we consider that our sister College of Medicine, which, like ours, is basically scientific, finds reason to complain in its ratio of 6.3:1, because this means disqualification from the rank of class A medical colleges in the United States. Under the burden of heavy teaching load, research activity necessarily has to be sacrificed, to the great detriment of instruction. Modernized versions of educational theories notwithstanding, in the natural sciences at least, there can conceivably be no college teacher that is not also a researcher. No teaching can inspire that consists mainly of warmed-over mental food.

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[a] These figures were obtained, not by tracing individual performance of each student during residence in college, but by mass calculation of annual totals furnished by the office of the secretary.

LEOPOLDO B. UICHANCO
Managing Editor

A STUDY OF THE BASE EXCHANGE PROPERTIES OF CERTAIN PHILIPPINE SOILS[1]

DIONISIO I. AQUINO
Of the Department of Soils

Base exchange, a characteristic property of soils, has for the last few years been the subject of study by several soil investigators. Its importance in soil economy is great, because by such exchange or replacement are the bases used by the plants largely rendered available. Some workers are of the opinion that base exchange is a chemical process while others claim that it is brought about by a physical adsorption. Each of these opinions suggests the cause for the fixation process and exchange reactions which take place in the soil.

The exact nature of the base exchange compounds in the soil is not very well understood so that these compounds are often referred to as the "exchange complex" or "humate-zeolite complex".

At the present time, it is quite generally recognized that base exchange occurs in the complex-aluminosilicate compounds which tend to react with a solution containing another replaceable base to effect replacement of the cations present in the silicate compounds. "When a salt solution containing replaceable bases is added to, or percolated through, a zeolitic soil, an exchange of bases takes place between the zeolite and the percolating solution". In other words the cation present in the salt solution combines with the acid radicals of the zeolitic soil, at the same time that the cation of the acid radicals is being displaced from the soil and goes into solution. The extent of this reaction is largely a function of the energy replacement of the cation in the salt solution and the nature and concentration of the base present in the soil complex.

The importance of the study of base exchange is now recognized by students of soil science. Numerous investigations on base exchange properties of soils were conducted by Gedroiz of Russia. His many contribution on the subject which were translated into English by Dr. S. A. Waksman of Rutgers College, New Jersey, aroused a great interest among many soil workers. Hissink (1923, 1926

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[1] Experiment Station contribution No. 1117. Received for publication November 1, 1935.

and 1928), Kelley (1926) and several soil investigators in the Bureau of Soils of the United States Department of Agriculture contributed a great deal to the study of the base exchange properties of soils.

The results obtained in the study of base exchange in the soil were used to advantage in the reclamation of alkali soils. Soil acidity, lime application, absorption of bases by plants, fixation and liberation of salts, as well as irrigation are some of the various complicated phases of soils work that are closely associated with the base exchange properties of soils. It is generally assumed that a soil with a relatively high base exchange property is usually fertile. Therefore, any quantitative determination of the replaceable bases of our soils would, undoubtedly, throw some light on their relative fertility.

REVIEW OF LITERATURE

The phenomenon of base exchange is a subject which is rather complicated. Extensive studies on this phenomenon were conducted in Russia and in the United States. In the Philippines, however, study on the subject has been rather scanty. The contributions of King and Guanzon (1929), Marfori[2], and Gestoso[3] deserve particular notice. In this paper an attempt is made to present only a short review of studies which have a direct bearing on the present investigation.

According to Kelley (1926), Way, about a quarter of a century ago, noted that when a sample of soil was treated with a solution of potassium chloride or other neutral salts, a part of the base of the salt was absorbed by the soil and an equivalent amount of calcium passed into solution.

Gedroiz and Hizzink, according to Kelley (1926) found that ion exchange in soils is subject to the principles of mass action and chemical equilibria, but that several cations differ considerably in their replacing activity.

The work of Burgess and Breazeale (1926) showed that one base may replace another base in the soil, hydrated aluminum silicate, or "zeolite". Calcium, for example, may replace sodium, and sodium in turn may replace calcium, depending upon the concentration of ions in solution. When a normal arable soil containing a considerable calcium is percolated with a solution of sodium chloride of sufficient concentration, an exchange of bases takes place. The sodium will replace the calcium and become "fixed" in the soil while the calcium will go into solution and come through the percolate as calcium chloride. This replacement will bring about a decided effect on the structural condition of the soil.

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[2] MARFORI, R. The replaceable bases in some Philippine soils. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Agriculture. 1929. Unpublished.)

[3] GESTOSO, FRANCISCO L. Basic exchange properties of some Laguna province soils. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Science in Agriculture. 1931. Unpublished.)

It was pointed out by McGeorge (1930 and 1931) that the exchange capacity of highly organic soils is approximately a linear function of the percentage carbon in the soil and that the base exchange takes place in a chemically equivalent proportion.

The results of the work of Kerr (1928) showed that the organic matter of the soil possesses a high base exchange capacity and that the base exchange material resides mostly in the clay fraction of the soil.

Page (1926) and Kelley and Arany (1928) pointed out that the inorganic constituents of non-alkali soils, sometimes referred to as zeolites, are chiefly calcium and magnesium compounds, with the former usually present in much greater amount.

Breazeale (1928 and 1929) advanced the idea that the presence of calcium carbonate in the aqueous solutions of all salts which are suitable for base replacement is responsible for many of the errors that come into replacement determination.

According to Magistad (1928) the presence of either calcium or magnesium zeolite in the soil is of great importance. These two zeolites do not hydrolyze readily as do the zeolites of potassium and sodium. Calcium and magnesium zeolites keep the soil flocculated and permeable to water, while potassium and sodium zeolites hydrolyze readily and tend to deflocculate soils. The retention or fixation of potassium and other bases in the soil is often, indirectly, a function of the quantity of the zeolites of calcium and magnesium.

Gatherwood and De Turk (1928) in their study of the relation of soil type to the exchangeable calcium and magnesium of some Illinois soils found that there was an apparent decrease in the amount of exchangeable calcium and magnesium as the maturity of soil increases. They also showed that the non-exchangeable calcium was fairly constant while the non-exchangeable magnesium varied somewhat among the different soil types.

It was claimed by Revikovitch (1930) that the amount of bases in the complex may increase or decrease depending on the kind of fertilizers added to the soil. Acid fertilizers brought about a marked decrease in the amount of the exchangeable bases as compared with the influence of the neutral or alkaline fertilizers. Ammonium sulfate showed a depressing influence as evidenced by the exhaustive action in removing the exchangeable calcium from the soil.

King and Guanzon (1929) in their study of the replaceable bases in some Philippine soils observed a correlation between the physical character of the soil and the replaceable bases. The results of their investigation showed that soils high in magnesium and sodium gave a low yield owing to their sticky, puddled and impermeable condition during the dry season which, in general, does not allow normal root development.

OBJECTS OF THE PRESENT WORK

The objects of the present investigation were: (*a*) to determine the amount of replaceable calcium and magnesium in soils; and (*b*) to determine their relative amounts in the different soil types in both the surface and subsoils.

MATERIALS AND METHODS

Soils. In this study soil samples collected by Dr. Robert L. Pendleton and thesis students under his supervision were used. The soil samples were thoroughly air-dried, pulverized and passed through a one-fourth millimeter sieve.

Description of the soil samples. The soils from Bokakeng forest management project, Baguio, Mountain Province were described by Pendleton and Aquino (1932). The description of the soil samples is presented in table 1. The soils of the Maquiling area are rather heavy in texture, ranging from loam, clay loam and clay.

Hernandez [4] in his study of the reaction and certain other characteristics of some soil samples from Occidental Negros showed that the soils were variable in texture, with silt loam and fine sandy loam predominating. The soils of the La Carlota and the Silay districts are mostly loam and sandy loam while those soils collected from Isabela district are mostly silt loam. The district of Binalbagan is represented by two types of soil, the silt loam and the fine sandy loam. The type of soil which is found to occur in most parts of the district of Bacolod is sandy loam. Most of the soil samples from

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[4] HERNANDEZ, SILVINO C. The reaction and certain other characteristics of some soil samples from Occidental Negros. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Agriculture. 1929. Unpublished.)

Manapla district are gravelly in nature. These field classifications of the soils were given by Pendleton (1927) which tallied very closely with the results secured by Oliveros[5] who studied the textural characteristics of some Philippine soils with the use of the centrifugal method.

Suebsaeng[6] described the Canlubang soils as fairly uniform in texture. According to him there was a predominance of clay loam tuff residual surface, subsoil, and substratum.

Method. The method used in the determination of the replaceable calcium and magnesium involves the use of 0.1 N $BaCl_2$ in alcoholic solution as suggested by Burgess and Breazeale (1926).

RESULTS

The results of this study are presented in tabulated form.

The description of the soil samples of the Baguio and the Maquiling area is shown in table 1.

Table 2 shows the averages of duplicate determinations of the amount of replaceable calcium and magnesium in the different soil types both in the surface and subsoils collected from Baguio, Mountain Province.

The data presented in table 3 show the amount of replaceable calcium and magnesium of the Maquiling area soils.

Table 4 shows the replaceable calcium and magnesium found in the soil samples from Canlubang, Laguna, and the districts of Silay, Isabela, Binalbagan, La Carlota, Bacolod and Manapla, Occidental Negros.

In table 5 are shown the average percentages of replaceable calcium and magnesium in the different soil series.

DISCUSSION OF RESULTS

The quantitative determination of replaceable calcium and magnesium presented in table 2 and summarized in table 5 shows that both calcium and magnesium contained in the soils of Baguio entered into chemical reaction in widely varying amounts. The replaceable calcium in the surface soils varies from 0.004 to 0.083 per cent with an average of 0.032 per cent. The replaceable calcium in the subsoils ranges from 0.002 to 0.116 per cent with an average of 0.030

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[5] OLIVEROS, SIMPLICIO. Mechanical analysis of some sugar cane soils. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Science in Agriculture. 1927. Unpublished.)

[6] SUEBSAENG, CHARUÑA. The hydrogen-ion concentration of certain sugarcane soils. (Thesis presented for graduation from the College of Agriculture with the degree of Bachelor of Science in Agriculture. 1928. Unpublished.)

per cent. The surface soils showed an amount of replaceable magnesium varying from zero to 0.039 per cent with an average of 0.007 per cent. The subsoils were found to contain small amounts of replaceable magnesium varying from zero to 0.039 per cent with an average of 0.004 per cent. In general, replaceable calcium is found to occur in greater amounts than magnesium in both the surface soils and the subsoils.

The soils of the Mirador series gave results similar to those shown by the soils of the Baguio series. The data also show that there was a greater amount of replaceable calcium in the surface soils than in the subsoils.

The presence of varying quantities of replaceable calcium and magnesium in the soils may be attributed to the textural characteristics of colloidal aggregates contained in the different soil types. The chemical behavior of the colloidal complexes depends to a certain extent on the proportion or amount of the various cations which the zeolites contain.

Pendleton and Aquino (1932) pointed out that the Baguio soils as described in table 1 have a loam to a clay loam surface with much organic matter, while the subsoils are mostly of a light clay loam to a stony clay and are sometimes composed of broken stones. The surface soils, in general, are heavier in texture than the subsoils. Heavy soils with much organic matter invariably contain more colloids than the light soils, hence the bases are tightly held by adsorption by the colloids. McGeorge (1930) in his study of the base exchange in peat and bog soils, showed that organic matter is very effective in the fixation of bases in soils by physical adsorption.

The soils of the Maquiling area as shown in table 3, which were used in this study were classified into two distinct series, the Calumpang and the Lipa series. The types of soils under the Calumpang series vary from loam to silty loam, clay loam and clay. The Lipa series is characterized by having only one type of soil, the clay loam type.

The average figures presented in table 5 show that the soils of the two series, the Calumpang and the Lipa series, do not show an appreciable difference in the amount of replaceable calcium and magnesium in the surface soils. It may be noted that the surface soils of the Calumpang series showed an amount of 0.024 per cent replaceable calcium and that of the Lipa surface soils, 0.023 per cent magnesium content. The amount of replaceable magnesium present in the surface soils of the Calumpang series was 0.024 per cent and 0.028 per cent was shown by the surface soils of the Lipa series.

The subsoils of the two series were found to contain approximately the same amount of replaceable calcium and magnesium in both the surface soils and the subsoils. The amount of these bases, however, is rather low as compared with that shown by the surface soils.

A comparison of the amount of calcium and magnesium in the Baguio soils with that present in the Maquiling area soils shows that the former contain more of the replaceable bases than the latter. This variation may be attributed to the difference in organic matter accumulation as influenced by climatic conditions and topographic situation. Baguio has a decidedly cooler climate than the areas around Mount Maquiling. A recent report by the Weather Bureau shows that the average annual temperature of Baguio, from the year 1901 to 1929, was 18°C. with an absolute maximum of 28.9°C. and an absolute minimum of 3.0°C. The average annual temperature around Manila, from 1880 to 1929 was 26.6°C. with an absolute maximum of 36.6°C. and an absolute minimum of 14.5°C. A greater accumulation of organic materials, therefore, is to be expected in the Baguio soils than in the soils of the Maquiling area. The general topography of Baguio is quite rough and very much higher in elevation than the Maquiling area.

That there were more replaceable bases in Baguio soils than in the Maquiling area soils may be explained by the degree of acidity as a characteristic property shown by each of the two groups of soils. Pendleton and Aquino (1932) found that the ten representative soil samples from Baguio which had been analyzed for their hydrogen-ion concentration showed an average pH value of 6.29 for the surface soils and pH 6.18 for the subsoils. Aquino and Villegas (1932) stated that the twelve representative soil samples of the Lipa series gave an average pH value of 5.76 for the surface soils and an average pH 5.75 for the subsoils. The average pH value of the twenty-two representative samples from the Calumpang series was 5.95 for the surface soils and a pH of 5.91 for the subsoils. It may be noted that in all cases the subsoils were found to be slightly more acidic than the surface soils.

From the results obtained it may be inferred that acidity may bring about a decrease in the amount of exchangeable bases, the greater the degree of acidity the less is the amount of replaceable bases. Kelley (1926) stated that acid soils are often found to be unsaturated with bases. Gedroiz, according to Kelley (1926) and Revikovitch (1930) pointed out the fact that the leaching action of acids such as carbonic acids and other organic acids resulted in the removal of the replaceable bases from the exchange complex. Marfori found that, in general, the total replaceable-base content of soils decreases as the hydrogen-ion concentration increases, resulting in the decrease in the pH value.

The sugar cane soils from the districts of Canlubang, Binalbagan, Silay, La Carlota, Bacolod, Isabela, and Manapla (table 4) varied in their content of replaceable calcium and magnesium. The amount of bases, apparently, was influenced by the physical character of the soils.

The soils of Canlubang, Isabela and Binalbagan were found to contain more replaceable bases than the soils of the other districts. This condition may be due to the relatively heavy texture of the soils. Because of the lighter texture of the soils from the other districts, it may be possible that the leaching process is more advanced in these soils than in the others which are relatively heavy textured soils.

An examination of the average percentages of replaceable calcium and magnesium in the different soil series used in this test, as recorded in table 5, showed that in the majority of cases the amounts of replaceable bases in the surface soils are relatively high as compared with those present in the subsoils. The average amount of replaceable calcium in the surface soils was 0.117 per cent or about 10.4 times as much as that contained in the subsoils which was only 0.012 per cent. The replaceable magnesium content of the surface soils was 0.064 per cent or about 17 times as much as the amount (0.004 per cent) present in the subsoils. This difference may very well be attributed to the heavy texture of the surface soils which invariably contain more colloids than the subsoils. Apparently, the bases are tightly held by adsorption, hence they are less easily leached by ordinary or natural leaching of rain.

A relative ratio of 1.8:1 was found to exist between the replaceable calcium and magnesium in the surface soils. This ratio was observed to be wider in the subsoils where it appeared to be 3:1.

Replaceable bases in relation to the crop-producing power of soils

The fertility of the soils, according to Kelley (1926) is intimately related to its exchange capacity. Other things being equal, the ability of the soils to stand up under artificial husbandry conditions is greatly influenced by their content of replaceable bases.

Henry (1928) described the soils of the districts of Isabela and Binalbagan as among the richest sugar cane soils in Occidental Negros. The soils of the other districts were found to be of medium production. He also stated that the soils of Canlubang, Laguna, gave a rather low yield as compared with the richest sugar cane soils of Negros. The reasons given were the non-progressive system of farming and the unfavorable rainy season.

The results of this study seemed to be in accord with Kelley's statement as given above. The soils of Isabela and Binalbagan described as rich soils were found to contain more replaceable calcium and magnesium than the other sugar cane soils of medium production. No conclusion however, may be made with respect to the Baguio soils which are from a particular set of climatic and topographic conditions or to the Canlubang soils, which according to Henry (1928), gave a low yield owing to the influence of various factors.

SUMMARY AND CONCLUSIONS

The results brought out in this study showed the base exchange properties of 98 representative soil samples of various series and types from Baguio, Mountain Province, Canlubang, Laguna and the districts of Isabela, Binalbagan, La Carlota, Silay, Bacolod and Manapla in Occidental Negros.

The surface soils and the subsoils of the different types used in the tests showed varying amounts of replaceable calcium and magnesium.

The amount of replaceable bases seemed to be greatly influenced by the physical character of the soils. The heavier soils were found to contain more replaceable calcium and magnesuim than the soils of comparatively lighter texture. This variation was attributed to the difference in organic matter accumulation as influenced by climatic conditions and the topographic situation.

The hydrogen-ion concentration shown by pH values of the different soils may have influenced the varying amounts of replaceable bases in the surface soils and the subsoils. It was apparent that the amount of replaceable bases in soils decreases as the hydrogen-ion concentration increases. This phenomenon may be due to the leaching action of acids as carbonic and other organic acids which resulted in the removal of the replaceable bases from the exchange complex.

Soils from the different districts of Occidental Negros showed significant variations in the amount of replaceable calcium and magnesium. The more fertile soils from the districts of Binalbagan and Isabela were found to be richer in replaceable bases than the soils of La Carlota, Silay, Bacolod and Manapla which are reputed to be of medium productivity.

The amount of replaceable bases, calcium and magnesium, in the soils from Baguio and Canlubang may not be taken as an index of their fertility because of particular set of conditions which might have influenced their base exchange capacity.

A ratio of 1.8:1 was observed to exist between the replaceable calcium and magnesium in the surface soils of various types. A wider ratio of 3:1 for replaceable calcium and magnesium appeared in the subsoils.

Because of the possibility that the amount of replaceable bases may influence the crop producing capacity of soils, it would seem to be desirable that further work on base exchange be undertaken of other soils of the Philippines.

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TABLE 1

Showing the description of the soil samples

SAMPLE NO.	DEPTH	DESCRIPTION
		BOKAKENG FOREST SOILS
	cm.	*Baguio series*
1-A	0-5	Dark gray loam with much organic matter
1-B	25-85	Yellowish brown silt loam
2-A	0-10	Dark gray light loam, much organic matter
2-B	25-60	Yellowish brown loam
6-B	15-40	Light brownish red light clay loam
7-B	20-45	Medium dark brown loam
8-A	0-20	Dark grayish brown silt loam
8-B	25-45	Medium brown broken stone
9-B	20-60	Brownish red light silty loam
10-A	0-30	Dark grayish brown loam
11-A	0-12	Dark brownish gray light clay loam
11-B	15-30	Medium yellowish brown light clay loam
12-A	0-5	Dark gray to black loam
12-B	10-20	Medium brown light clay loam
13-A	0-15	Dark brown silt loam
13-B	25-45	Medium reddish brown light silty clay loam
14-A	0-20	Dark grayish brown clay loam
14-B	25-40	Medium grayish brown gravelly clay loam
18-A	0-15	Brownish red clay loam
18-B	20-40	Brownish red clay loam
		Mirador series
3-A	0-10	Dark gray light clay loam
4-A	0-20	Medium grayish heavy loam to light clay loam
5-A	0-10	Dark grayish brown light silt loam
5-B	20-40	Light brownish clay loam
		MAQUILING AREA SOILS
		Calumpang series
1-A	0-25	Brownish to dark brownish gray clay
1-B	30-60	Brown to bluish gray clay
5-B	27-64	Light yellowish brown clay
8-A	0-30	Brown light clay loam
8-B	35-60	Brownish clay loam
10-A	0-60	Dark brown loam
11-A	0-25	Brownish gray to dark brown clay loam
12-B	25-50	Dark gray clay
13-A	0-25	Brownish clay loam
14-B	25-60	Dark brown light silty clay loam
15-A	0-30	Grayish brown clay loam
16-A	0-45	Dark brownish gray loam
17-B	25-60	Brown to bluish gray clay
		Lipa series
28-A	0-25	Dark brown clay loam
31-B	35-70	Medium brown clay loam
33-A	0-15	Dark brown clay loam
33-B	20-45	Light brown clay loam

TABLE 2

Showing the amount of replaceable calcium and magnesium of soils from Bokakeng forest management project, Mountain Province [a]

Baguio series

SAMPLE NO.	REPLACEABLE BASES OF 0.1 N $BaCl_2$ EXTRACT PER 100 GRAMS OF OVEN DRY SOIL			
	Calcium		Magnesium	
	Av. in grams	*per cent*	*Av. in grams*	*per cent*
1-A	0.08250	0.083	0.00975	0.010
1-B	0.05625	0.056	0.03900	0.039
2-A	0.06375	0.064	0.03900	0.039
2-B	0.01875	0.019	—	—
6-B	0.03925	0.039	—	—
7-B	0.02625	0.026	—	—
8-A	0.07875	0.079	0.00487	0.005
8-B	0.11625	0.116	—	—
9-B	0.00375	0.004	—	—
10-A	0.03750	0.038	0.00585	0.006
11-A	0.06750	0.068	0.00429	0.004
11-B	0.00750	0.008	—	—
12-A	0.01875	0.019	—	—
12-B	0.00375	0.004	—	—
13-A	0.00375	0.004	—	—
13-B	0.00375	0.004	0.00390	0.004
14-A	0.01225	0.012	—	—
14-B	0.05250	0.052	0.00390	0.004
18-A	0.00375	0.004	—	—
18-B	0.00225	0.002	—	—
	Mirador series			
3-A	1.10812	1.108	0.09263	0.093
4-A	0.04875	0.049	0.00195	0.002
5-A	0.02675	0.027	—	—
5-B	0.05625	0.056	0.00097	0.001

[a] The figures are averages of duplicate determinations.

TABLE 3

Showing the amount of replaceable calcium and magnesium of the Maquiling area soils

Calumpang series

SAMPLE NO.	REPLACEABLE BASES OF 0.1 N $BaCl_2$ EXTRACT PER 100 GRAMS OF OVEN DRY SOIL			
	Calcium		Magnesium	
	Av. in grams	*per cent*	*Av. in grams*	*per cent*
1-A	0.01125	0.011	0.00095	0.011
1-B	0.00165	0.002	—	—
5-B	0.02250	0.023	0.01072	0.011
8-A	0.01750	0.018	—	—
8-B	0.01550	0.016	—	—
10-A	0.02300	0.023	0.00097	0.001
11-A	0.02300	0.023	—	—
12-B	0.05250	0.053	0.00487	0.005
13-A	0.04870	0.049	0.00487	0.005
14-B	0.03375	0.034	0.00585	0.006
15-A	0.02625	0.026	0.00195	0.002
16-A	0.01550	0.016	0.00195	0.002
17-B	0.03750	0.038	0.00487	0.005

Lipa series

28-A	0.01875	0.019	0.00097	0.001
31-B	0.04125	0.041	0.00195	0.002
33-A	0.02675	0.027	0.00780	0.009
33-B	0.01550	0.016	0.00585	0.006

TABLE 4

Showing the amount of replaceable calcium and magnesium of Occidental Negros soils

Silay, Occidental Negros, soils

SAMPLE NO.	REPLACEABLE BASES OF 0.1 N $BaCl_2$ EXTRACT PER 100 GRAMS OF OVEN DRY SOIL			
	Calcium		Magnesium	
	Av. in grams	*per cent*	*Av. in grams*	*per cent*
1-A	0.05650	0.057	0.05570	0.056
1-B	0.06375	0.064	—	—
4-A	0.04365	0.044	—	—
8-A	0.07350	0.074	—	—
8-B	0.10870	0.110	—	—
18-A	0.04135	0.041	0.00575	0.006
18-B	0.02435	0.024	0.00465	0.005
21-A	0.10735	0.110	—	—
21-B	0.06135	0.061	—	—
23-A	0.01875	0.019	—	—
23-B	0.01650	0.017	—	—
24-B	0.00275	0.003	—	—
26-A	0.02525	0.025	0.00185	—
26-B	0.01375	0.014	—	—
Isabela, Occidental Negros, soils				
2-A	0.07530	0.076	0.05525	0.056
2-B	0.06550	0.067	0.03250	0.033
3-A	0.09325	0.093	0.00975	0.010
3-B	0.08275	0.083	0.00625	0.006
5-A	0.13275	0.133	0.00195	0.002
5-B	0.13275	0.133	—	—
7-A	0.30115	0.301	—	—
14-A	0.31150	0.312	0.00195	0.002
14-B	0.25175	0.252	0.00195	0.002
Binalbagan, Occidental Negros, soils				
10-A	0.21375	0.214	0.00585	0.006
10-B	0.19875	0.199	0.00585	0.006
13-A	0.10125	0.101	0.00595	0.006
13-B	0.10125	0.101	0.00195	0.002
15-A	0.20175	0.202	0.00925	0.010
16-A	0.10125	0.101	0.00585	0.006
16-B	0.10075	0.101	0.00925	0.010

TABLE 4 (Continued)

La Carlota, Occidental Negros, soils

SAMPLE NO.	REPLACEABLE BASES OF 0.1 N $BaCl_2$ EXTRACT PER 100 GRAMS OF OVEN DRY SOIL			
	Calcium		Magnesium	
	Av. in grams	*per cent*	*Av. in grams*	*per cent*
15-A	0.14625	0.146	0.00195	0.002
15-B	0.10875	0.109	—	—
16-A	0.10175	0.102	—	—
16-B	0.13125	0.131	—	—
18-A	0.09375	0.094	0.00195	0.002
Bacolod, Occidental Negros, soils				
26-A	0.01875	0.019	—	—
26-B	0.02625	0.026	—	—
29-A	0.00275	0.003	—	—
29-B	0.00195	0.002	—	—
Manapla, Occidental Negros, soils				
39-A	0.03375	0.034	0.00585	0.006
39-B	0.02150	0.022	—	—
40-A	0.04875	0.049	0.00975	0.010
40-B	0.02625	0.027	—	—
43-A	0.09125	0.091	—	—
43-B	0.02575	0.026	—	—
Canlubang, Laguna, soils				
204	0.18625	0.186	0.00585	0.006
205	0.19875	0.199	0.00585	0.006
212-A	0.35575	0.356	0.00985	0.010
212-B	0.26525	0.265	0.00195	0.002
295	0.27375	0.274	0.00195	0.002
296	0.28775	0.288	0.00585	0.009
319-A	0.27375	0.274	0.01975	0.020
319-B	0.20250	0.203	0.01595	0.016
320	0.25525	0.255	—	—
328	0.18625	0.186	0.00195	0.002
330-A	0.13275	0.133	0.00195	0.002
330-B	0.10870	0.109	—	—

TABLE 5

Showing the average percentages of replaceable calcium and magnesium in the different soil series

	SURFACE SOIL		SUBSOIL	
	Calcium	Magnesium	Calcium	Magnesium
Bokakeng forest soils				
Baguio series	0.032	0.007	0.030	0.004
Mirador series	0.394	0.056	0.032	0.001
Maquiling area soils				
Calumpang series	0.024	0.024	0.003	0.005
Lipa series	0.023	0.028	0.005	0.004
Canlubang, Laguna, soils	0.240	0.123	0.007	0.009
Occidental Negros soils				
Silay series	0.053	0.043	0.031	0.005
Isabela series	0.183	0.134	0.018	0.014
Binalbagan series	0.154	0.134	0.001	0.006
La Carlota series	0.114	0.120	0.002	—
Bacolod series	0.011	0.014	—	—
Manapla series	0.058	0.025	0.008	—
Average	0.117	0.064	0.012	0.004

A PRELIMINARY STUDY OF THE COMPARATIVE EFFECTS UPON THE YIELDS OF SUGAR CANE OF FERTILIZING WITH AMMONIUM SULFATE AND WITH GREEN MANURE[1]

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WITH ONE PLATE AND ONE TEXT FIGURE

In the culture of sugar cane it is now a practice to supply to some degree the plant food lacking in the soil by the application of commercial fertilizers. Occasionally, green manuring with legumes, one of the cheapest means of increasing the soil fertility and improving the soil is used. Because of the heavy expense incurred in maintaining the fertility of the land by the application of commercial fertilizers it should be of interest to know the comparative initial effects of commercial fertilizer and green manure on the plant crop and their comparative residual effects on the succeeding ratoon crop. Hence, this study was undertaken.

It appears from the general survey of literature that in the Philippines experiments on sugar cane fertilization have been largely with commercial fertilizers, little has been done to determine the effects of green manures upon the crop. It appears also from the survey of available references from various parts of the world that in most cases green manuring is of definite benefit in improving the soil and consequently improving the yield of sugar cane.

The present work had for its objects the following: (*a*) to determine the comparative effects of ammonium sulfate fertilizer and green manure upon the yields of cane and sugar and piculs sugar per ton cane of the plant crop; and (b) to determine the comparative residual effects of ammonium sulfate and green manure upon the yields of cane and sugar and piculs sugar per ton cane of the succeeding ratoon crop.

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[1] Portions of the material in this paper were taken from the thesis presented by the junior author for graduation, 1934, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture No. 497; Experiment Station contribution No. 1118.

Read before the Los Baños Biological Club August 29, 1935. Received for publication October 16, 1935.

The work was carried out by the senior author from 1932 to 1933 and by both authors from 1933 to 1934 in the Experiment Station of the College of Agriculture, University of the Philippines.

MATERIALS AND METHODS

Field and variety of sugar cane used. The soil is clay loam. The field used was divided into 30 plots, 15 meters by 20 meters and these plots were given treatments as follows:

(1) Six plots were fertilized with ammonium sulfate containing 20 per cent nitrogen.

(2) Six plots were green-manured with cowpea, *vigna sinensis* (Linn.) Savi.

(3) Six plots were green-manured with mungo, *Phaseolus aureus* (Roxb.)

(4) Six plots were green-manured with soybean, *Glycine max* (Linn.) Merr.

(5) Six plots were given no treatment and served as control.

The cane variety POJ 2878 was used in this study.

Preparation of the land and planting of legumes. The land was thoroughly prepared by plowing and harrowing several times before the legume seeds were broadcast on the plots. Cowpea was sown at the rate of 1.71 liters per plot or 57.14 liters per hectare; mungo at 2.47 liters per plot or 85.71 liters per hectare; and soybean at 1.71 liters per plot or 57.14 liters per hectare. The plants were turned under at the blooming stage when they were supposed to have available the highest amount of nutrient material.

Observations on green manure cultures. The legumes were closely observed in the field. The number of days from planting to germination and from planting to flowering was recorded.

Fertilization. The ammonium sulfate, the fertilizer used in this experiment, was broadcast in the furrows just before planting at the rate of 375 kgm. per hectare.

The plant crop

Planting of the crop. In the plant crop, cut-back seed pieces were used as planting material. The seed-pieces were prepared in the usual manner, and were from 25 to 30 cm. long. They were soaked for some time in running water before they were planted in the furrows. The distance between the furrows was 100 cm. and between hills in the furrows, 40 cm. The hills were arranged in quincunx.

Replanting and care of the plant crop. Because a low percentage of germination of the seed pieces was obtained, the missing hills were replanted. The plants from two of the plots of each of those green-manured with cowpea, mungo, or soybean were used for replanting the missing hills of the different treatments. The usual care was given the plant canes up to maturity.

Harvesting and determination of yields. The canes were harvested in March, 1933 and the yields of the different plots were recorded separately.

The crusher juice of the canes from each plot was analysed and the degree Brix and percentage of polarization were recorded. From these data, the apparent purity, base per cent sugar, piculs sugar per hectare and piculs sugar per ton cane of each plot were determined by the use of Warren's table and the *Chemical Control for Cane Sugar Factories*, prepared by the Association of Hawaiian Sugar Technologist (1921).

The ratoon crop

Cultivation. On April 10, 1933, a few weeks after the plant crop was harvested, the cane trash was burned.

Each plot was cultivated four times. The cultivation consisted of alternate off-barring and hilling-up. On May 15, 1933, the first off-barring was done. On June 10, 1933 the canes were hilled-up for the first time. On this date the canes were over two months old and were about a meter high. The canes were again off-barred on June 25, 1933. The last cultivation, hilling-up or closing-in, was on July 2, 1933.

Determining percentage of stand of sugar cane. The percentage of stand of cane plants in each plot was determined when the plants were about a month old and 30 cm. tall. The percentage of stand of plants was determined by going over the rows and recording the number of living hills in the rows of the different plots. The missing hills of the ratoon crop were not replanted.

Harvesting and determination of yields. The canes were harvested from February 22 to 24, 1934. They were harvested, weighed and analysed separately. The canes were milled in the College Sugar Mill.

The crusher juice of the canes from each plot was analysed and the degree Brix and percentage of polarization were recorded. From these data the apparent purity, base per cent sugar, piculs sugar per hectare and piculs sugar per ton cane of each plot were determined.

RESULTS AND DISCUSSIONS

The results of this study are presented in tables 1-7 and plate 1 and figure 1.

Observation on green-manure cultures. The legumes germinated 3 to 4 days after planting. The mungo reached the flowering stage in 37-44 days; the soybean (Ami variety) and the cowpea (New Era variety) in 37-46 days.

Results on the plant crop

The results on the plant crop are presented in tables 1-5, plate 1 and figure 1.

Comparative germination. Table 1 shows the percentage of germination under the different treatments. It may be seen in table 1 and figure 1 that in all different treatments there was a low percentage of germination, ranging from an average of 17 to 37.66 per cent. The control plots had the highest percentage of germination and the green-manured plots the lowest. This high percentage of mortality may in part be due to the dry condition of the soil in the field,[2] which was below the optimum for germination. Calma (1933) reported that 25 per cent moisture was about the optimum for germination of POJ 2878. It also may have been due to the severe infestation of termite *Macrotermis gilvus* Hagen and the infection of pineapple disease. When some of the seed pieces were dug up and examined they were found to be badly attacked by termites and severely infected with pineapple disease, as shown in tables 2 and 3 and plate I. This condition was found in all of the different treatments.

It may be seen in table 2 that the green-manured plots had the highest termite infestation; it ranged from an average of 64.33 to 76.5 per cent; the plots fertilized with ammonium sulfate had the lowest infestation, with an average of only 36 per cent. There was also a high percentage of pineapple disease infection, ranging from an average of 62.23 to 83 per cent (table 3). The green-manured plots had the highest average percentage of pineapple disease infection; it ranged from 77.83 to 83 per cent. The control plots had the lowest with an average of only 62.33 per cent. There seemed to be a positive correlation between termite infestation and pineapple disease infection and mortality of the seed pieces; that is, in general where there was a high percentage of termite infestation and pineapple disease infection, there was a high percentage of mortality of seed pieces. Evidently, the absence of sufficient moisture supply for germination weakened the tissues of the seed pieces and rendered them more susceptible to the attack of the termites and pineapple disease. In the absence of a supply of sufficient moisture or in the presence of intermittent water supply, germination of the seed piece may be greatly prolonged. It has been frequently observed by the senior writer that under dry conditions cane points can remain in the soil with but a slight modification, such as production of certain amount of fibrous roots, for periods as long as six weeks or more and yet continue perfectly viable. Undoubtedly, the termites and pineapple disease contributed to the high mortality of the seed pieces. The termites might have damaged the seed pieces in two ways, by eating the eyebuds directly and by making a wound and openings which might have served as entrance for the pineapple disease organism, which in turn, might have infected the eyebuds of the seed pieces. Goseco, (1925) found that it took 15-18 days for cowpea vines to decay when turned under as green manure. Lazo (1929) and Alonzo (1934) studying the rate of decomposition of legumes under Los Baños conditions reported that in the field the termites ate the green manures. Lazo (1929) also reported that green manures turned under in the field, in most cases would be eaten by the termites within three weeks. Alonzo (1934) found that seven of the nine different green manures he studied were partly or wholly eaten by termites when turned under. In the present study, the seed pieces were planted 14 days after turning under the green manures. Undoubtedly, the presence of undecomposed green manure produced a soil condition favorable to the development of the termites, and predisposed the seed pieces to the destruction of the pest. The arrangement of the plots may explain the heavy infestation with termites and infection with pineapple disease of the control and of the plots fertilized with ammonium sulfate. The plots of the different treatments were arranged in checkerboard fashion and the plots fertilized with ammonium sulfate and control were laid side by side or in between the green-manured plots. The plots were each 15 meters by 20 meters or 300 square meters, only. Evidently, termites and the pineapple disease organism in the green-manured plots had passed to the control and the plots fertilized with ammonium sulfate.

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[2] Analyses of soil by the senior author of an adjoining cane field at the time of the experiment, March 7, 1932 gave only 16.37 per cent moisture.

As to whether the decomposition of the green manure affected the germination of the seed pieces of sugar cane is doubtful and remains to be determined. According to Pieters (1927) Fred studied the effects of green manures on the germination of various seeds, as cotton, soybean, flax, hemp, mustard, peanuts, clover, corn, and oats. He found that when cotton was planted immediately after a green manure crop was turned under, germination was prevented or seriously retarded, depending on the quantity of green manure turned under. Soybeans were also found to be sensitive but corn and oats were not injured. As a rule, oil seeds were readily damaged while starchy seeds were not. Pieters (1927) recommends that the seeds should not be planted until two weeks after the green manure is turned under. Since sugar cane stores its food in the form of sucrose, which is also a carbohydrate, it is very likely that the germination of the seed pieces was not affected by the decomposition of the green manure. Furthermore, the seed pieces were planted fourteen days after the green-manures were turned under.

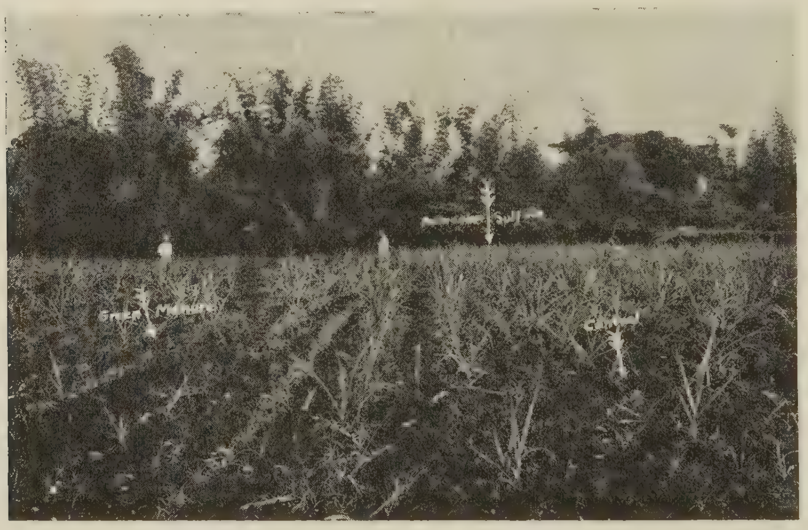
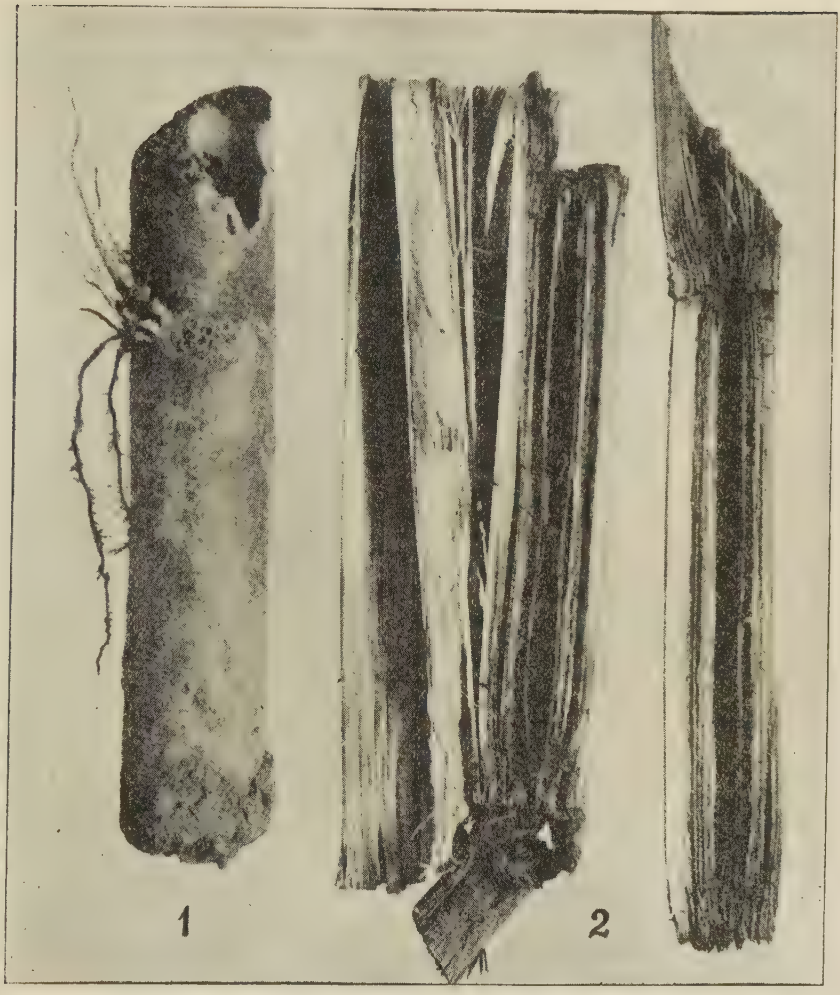


Fig. 1.—Showing a field fertilized with ammonium sulfate and green-manured with cowpeas, *Vigna sinensis* (Linn.), Savi, mungo, *Phaseolus aureus* Roxb., and soybeans, *Glycine max* (Linn.) Merr. Note the poor stand resulting from the attack of termites, *Macrotermis gilvus* Hagen and pineapple disease caused by *Ceratostomella paradoxa*, Dade (*Thielaviopsia paradoxa* (De Seyn Von Hoehnel). Note the many missing hills at the left caused by the severe infestation of termites and the infection of pineapple disease in the green-manured plots. At the right are the plots fertilized with ammonium sulfate and the control. The photograph was taken 86 days after planting.

(Photograph by Photographic Division of the Department of Soils.)



EXPLANATION OF PLATE I

Showing two seed pieces of POJ 2878 sugar cane dug up after being in the ground several weeks. They were found to have been killed by the combined attack of termites *Macrotermis gilvus* Hagen and pineapple disease caused by *Ceratostomella paradoxa* Dade (*Thielaviopsis paradoxa* De Seyn. Von Hoehnel).

Fig. 1.—Showing a body or cut-back seed piece that had been eaten at each end by termites.

Fig. 2.—Showing a top seed piece split open. At the left is one-half of the seed piece with the leaf sheath still attached, and at the right is the other half with the leaf sheath detached. A "pipe" was formed in the interior as may be seen in the center of each of the halves of the seed piece. The sooty-black spores of the fungus imparted a dark color to the "pipe".

(Photograph by the Photographic Division of the Department of Soils).

Comparative stand. The results in table 4 indicate that even after replanting was done, the green-manured plots were still more susceptible to termite infestation and pineapple disease infection than the control or the plots fertilized with ammonium sulfate.

Comparative behavior of plants of the different treatments. On the whole, the fertilized and green-manured lots produced more vigorous plants than the control. There was nothing uncommon observed in the flowering habit of plants receiving the different treatments; flowering was first observed on October 20, 1932.

Comparative yields of cane and sugar and piculs sugar per ton cane of the different treatments. It may be seen in table 5 that the plots fertilized with ammonium sulfate and the control gave significantly higher yields of both cane and sugar per hectare than the green-manured plots. The results may be explained by the fact that the green-manured plots had a comparatively much lower percentage of germination and stand than either the control plots or those fertilized with ammonium sulfate. The stools of the replanted hills might not have developed normal-sized stalks as replanting was done as late as August. The high yields of both cane and sugar of the plots fertilized with ammonium sulfate might be due also to the immediate beneficial effects of the fertilizer. There was, however, no significant difference in the yields of cane and sugar between the plots fertilized with ammonium sulfate and the control, owing probably, to the fact that the control plots had a higher percentage of germination and stand than the fertilized plots, which might have offset the beneficial effects of the fertilizer. Likewise, there was no significant difference in yields of cane and sugar between the different green-manured plots. This superiority of ammonium sulfate to the other treatments may be due to its immediate beneficial effects.

Results on ratoon crop

Comparative degree of tillering of the different treatments. The results shown in table 6 indicate that green-manure and ammonium sulfate fertilizer applied to the preceding plant crop had no effect on the number of millable stalks produced by the succeeding ratoon crop.

Comparative vigor of plants of the different treatments. On the whole, the plots fertilized with ammonium sulfate or green-manured with mungo, cowpea, or soybean were observed to produce more vigorous plants than the control. Their leaves were green, wide and spreading.

Comparative maturity of plants of the different treatments. There was nothing uncommon observed in the flowering habits of the plants receiving different treatments. They all flowered at about the same time; the first flowering was observed on October 20, 1933. Most of the canes in all of the treatments were in bloom by October 28, 1933. This observation indicates that the maturity of POJ 2878 ratoon canes is not influenced at all by the effect of green manures and ammonium sulfate fertilizer applied to the preceding crop.

Comparative yields of cane and sugar and piculs sugar per ton cane under the different treatments. On the whole, the results shown in table 7 indicate that the application of ammonium sulfate fertilizer on the plant crop did not have any beneficial effect on the yields of cane, sugar and piculs sugar per ton cane of the succeeding ratoon crop. It is interesting to note, however, that the yields of cane and sugar and piculs sugar per ton cane of the ratoon crop of the green-manured plots were greater than those of their corresponding plant crop. Nevertheless, the yields of cane and sugar of the ratoon crop of the plots fertilized with ammonium sulfate and the control were only about half as much as those of their corresponding plant crop. Furthermore, it is of interest to note that in spite of the fact that the ratoon of the control plots had a much higher percentage of stand than that of the green-manured plots, the plots green-manured with mungo, gave higher yields of cane and sugar than the control and those green-manured with soybean or cowpea gave practically the same yield as the control plots. These results might be due partly to the beneficial residual effects upon the succeeding ratoon crop of the green manures applied to the plant crop. That the ratoon crop of the green-manured plots gave higher yields of cane and sugar and piculs sugar per ton cane than their corresponding plant crop might be due partly also to late and many replantings made in the plant crop. The stools of the replanted hills in the plant crop might not have developed normal-sized stalks and might not have attained full maturity as replanting was made as late as August.

SUMMARY OF RESULTS

In an attempt to study the comparative initial effects of ammonium sulfate fertilizer and different legumes as green manures on the cane plant and their residual effects on the succeeding ratoon crop, this investigation was conducted. The results obtained from this study may be summarized as follows:

1. The three different legumes germinated in 3 to 4 days after planting. It took 37-44 days for mungo to reach the flowering stage, and 37-46 days for Ami soybeans and new Era cowpea.

2. The different treatments gave very low percentage of germination ranging from an average of 17 to 37.67 per cent. The control plots had the highest average percentage of germination and the green-manured plots the lowest. This high mortality of the seed pieces might be due to the severe infestation of termite and infection of pineapple disease.

3. The termite infestation ranged from an average of 36 to 76.5 per cent. The green-manured plots had the highest termite infestation and the plots fertilized with ammonium sulfate the lowest. The pineapple disease infection ranged from an average of 62.33 to 83 per cent. The green-manured plots had the highest percentage of pineapple disease infection and the control the lowest. The presence of very large numbers of termites and prevalence of pineapple disease in the plots fertilized with ammonium sulfate and in the control plots might have been due to their contamination by the green-manured plots, as these plots were only 300 square meters in size and were arranged in checkerboard fashion.

4. The green-manured plots each had less than 75 per cent stand, while the control plots and those fertilized with ammonium sulfate had each about 85 per cent stand.

5. When the numbers of millable stalks per stool produced by the plots green-manured with cowpea, mungo, and soybean were compared with those of the control, the differences were statistically insignificant but the control had the most. The plots fertilized with ammonium sulfate produced more millable stalks than the control, but the difference was insignificant.

The control plots produced significantly more non-millable stalks per stool than any of the green-manured plots. But the control plots and those fertilized with ammonium sulfate produced practically the same number of non-millable stalks per stool.

6. The plots fertilized with ammonium sulfate and those green-manured with cowpea, mungo, or soybean produced more vigorous plants than the control.

7. The plants of the different treatments flowered at about the same time.

8. The plant crop of the plots fertilized with ammonium sulfate and the control gave significantly higher yields of both cane and sugar per hectare than the green-manured plots. The plots fertilized

with ammonium sulfate and the control had each more than 50 tons cane and 99 piculs of sugar per hectare, while the green-manured plots had each less than 30 tons cane and 57 piculs of sugar per hectare. The plots fertilized with ammonium sulfate gave significantly higher piculs sugar per ton cane than those of the other treatments. With but one exception, that is, the plots green-manured with mungo and the control, there was no significant difference in the yield of piculs sugar per ton cane of the other treatments.

9. In the ratoon crop, the plots green-manured with mungo gave the highest yields of cane and sugar per hectare with 36.019 ± 1.68 tons and 76.154 ± 3.58 piculs sugar, respectively; the plots fertilized with ammonium sulfate and the control had each about 33 tons cane and 68 piculs sugar per hectare; the plots green-manured with soybean and cowpea had each about 30 tons cane and 60 piculs sugar per hectare. The yields in piculs of sugar per ton cane of the different treatments were practically the same.

10. On the whole, the results indicate that the application of ammonium sulfate fertilizer on the plant crop has an immediate beneficial effect on the yields of cane and sugar per hectare and piculs sugar per ton cane, but does not have any effect on the yield of the succeeding ratoon crop.

The results seem to indicate that the green manures applied to the plant crop had a beneficial residual effect upon the succeeding ratoon crop.

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TABLE 1

Showing the percentage of germination under the different treatments

TREATMENTS	GERMINATION						
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Average
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Control	27	46	29	43	41	40	37.66
Ammonium sulfate ..	34	35	17	31	13	18	24.66
Soybean	20	40	14	20	22	17	22.16
Cowpea	8	12	24	38	15	31	21.33
Mungo	11	13	34	17	18	9	17.00

TABLE 2

Showing the percentage of termite infestation under the different treatments

TREATMENTS	TERMITE INFESTATION						
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Average
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Control	58	43	60	42	54	30	47.83
Ammonium sulfate ..	54	65	15	10	20	52	36.00
Soybean	76	55	68	70	70	58	66.16
Cowpea	92	86	70	59	83	69	76.50
Mungo	85	87	43	78	36	57	64.33

TABLE 3

Showing the percentage of pineapple disease infection under the different treatments

TREATMENTS	PINEAPPLE-DISEASE INFECTION						
	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Average
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Control	73	54	71	57	59	60	62.33
Ammonium sulfate ..	66	65	83	69	87	82	75.33
Cowpea	92	88	76	62	35	69	78.66
Soybean	80	60	86	80	78	83	77.83
Mungo	89	87	66	83	82	91	83.00

TABLE 4

Showing the percentage of stand under the different treatments

TREATMENTS	STAND				
	Plot 1	Plot 2	Plot 3	Plot 4	Average
	per cent	*per cent*	*per cent*	*per cent*	*per cent*
Control	86.4	88.0	80.0	91.2	86.40
Ammonium sulfate	87.2	86.4	76.0	81.6	82.80
Soybean	85.6	81.6	60.8	66.4	73.60
Cowpea	79.2	84.8	58.4	69.6	73.00
Mungo	57.6	84.0	65.6	80.8	72.00

TABLE 5

Showing the comparative degree of tillering under the different treatments (Ratoon crop)

TREATMENTS	AVERAGE NUMBER OF STALKS PER STOOL (100 STOOLS COUNTED)			
	Millable		Non-millable	
	Number of stalks	Difference	Number of stalks	Difference
Control	4.72 ± 0.14		0.98 ± 0.06	
Ammonium sulfate	5.06 ± 0.18	0.34 ± 0.23 (Insignificant)	0.81 ± 0.05	0.17 ± 0.08 (Insignificant)
Cowpea	4.49 ± 0.24	0.23 ± 0.28 (Insignificant)	0.66 ± 0.06	0.32 ± 0.08 (Significant)
Mungo	4.54 ± 0.28	0.18 ± 0.32 (Insignificant)	0.62 ± 0.05	0.36 ± 0.08 (Significant)
Soybean	4.52 ± 0.07	0.20 ± 0.16 (Insignificant)	0.60 ± 0.08	0.38 ± 0.10 (Significant)

TABLE 6

Showing the comparative average yields of cane and sugar per hectare and piculs sugar per ton cane under the different treatments

(Plant Crop)

TREATMENTS	AV. YIELD OF CANE PER HA.		AV. YIELD OF SUGAR PER HA.		AV. YIELD OF SUGAR PER TON CANE	
	Yield	Difference	Yield	Difference	Yield	Difference
	tons	*tons*	*piculs*	*piculs*	*piculs*	*piculs*
Control	50.900 ± 4.55		99.958 ± 7.78		1.99 ± 0.03	
Cowpea	29.183 ± 1.82	21.717 ± 4.89 (Significant)	56.328 ± 4.11	43.630 ± 8.80 (Significant)	1.92 ± 0.03	0.07 ± 0.03 (Insignificant)
Mungo	24.916 ± 2.23	25.984 ± 5.07 (Significant)	46.249 ± 5.09	53.709 ± 9.30 (Significant)	1.86 ± 0.03	0.13 ± 0.03 (Significant)
Soybean	25.425 ± 4.15	25.475 ± 6.16 (Significant)	48.196 ± 8.35	51.762 ± 11.41 (Significant)	1.88 ± 0.04	0.11 ± 0.05 (Insignificant)
Ammonium sulfate	70.483 ± 8.03	–19.583 ± 9.23 (Insignificant)	148.286 ± 16.35	–48.328 ± 18.03 (Insignificant)	2.13 ± 0.03	–0.14 ± 0.03 (Significant)
Ammonium sulfate [a]	70.483 ± 8.03		148.286 ± 16.35		2.13 ± 0.03	
Cowpea	29.183 ± 1.82	41.300 ± 8.23 (Significant)	56.328 ± 4.11	91.958 ± 16.86 (Significant)	1.92 ± 0.03	0.21 ± 0.03 (Significant)
Mungo	24.916 ± 2.23	45.567 ± 8.33 (Significant)	46.249 ± 5.09	102.037 ± 17.11 (Significant)	1.86 ± 0.03	0.27 ± 0.03 (Significant)
Soybean	25.425 ± 4.15	45.058 ± 9.04 (Significant)	48.196 ± 8.35	100.090 ± 18.36 (Significant)	1.88 ± 0.04	0.25 ± 0.05 (Significant)
Cowpea [b]	29.183 ± 1.82		56.328 ± 4.11		1.92 ± 0.03	
Mungo	24.916 ± 2.23	4.267 ± 2.87 (Insignificant)	46.249 ± 5.09	10.079 ± 6.87 (Insignificant)	1.86 ± 0.03	0.06 ± 0.03 (Insignificant)
Soybean	25.425 ± 4.15	3.758 ±4.53 (Insignificant)	48.196 ± 8.35	8.132 ± 9.31 (Insignificant)	1.88 ± 0.04	0.04 ± 0.05 (Insignificant)
Mungo [c]	24.916 ± 2.23		46.249 ± 5.09		1.86 ± 0.03	
Soybean	25.425 ± 4.15	–00.509 ± 4.72 (Insignificant)	48.196 ± 8.35	–1.947 ± 9.78 (Insignificant)	1.88 ± 0.04	–0.02 ± 0.05 (Insignificant)

[a] Ammonium sulfate was used as the basis for comparison.
[b] Cowpea was used as the basis for comparison.
[c] Mungo was used as the basis for comparison.

TABLE 7

Showing the comparative average yields of cane and sugar per hectare and piculs sugar per ton cane under the different treatments

(Ratoon Crop)

TREATMENTS	AV. YIELD OF CANE PER HA.		AV. YIELD OF SUGAR PER HA.		AV. YIELD OF SUGAR PER TON CANE	
	Yield	Difference	Yield	Difference	Yield	Difference
	tons		*piculs*		*piculs*	
Control	32.939 ± 1.57		66.401 ± 3.27		2.015 ± 0.03	
Cowpea	29.513 ± 1.67	3.426 ± 2.29 (Insignificant)	58.703 ± 3.43	7.698 ± 4.74 (Insignificant)	1.988 ± 0.04	0.027 ± 0.05 (Insignificant)
Mungo	36.019 ± 1.68	–3.080 ± 2.30 (Insignificant)	76.154 ± 3.58	–9.753 ± 4.85 (Insignificant)	2.114 ± 0.01	–0.099 ± 0.03 (Insignificant)
Soybean	29.332 ± 0.49	3.607 ± 1.64 (Insignificant)	62.221 ± 1.47	4.180 ± 3.59 (Insignificant)	2.121 ± 0.03	0.106 ± 0.04 (Insignificant)
Ammonium sulfate ..	33.737 ± 1.73	–0.798 ± 2.34 (Insignificant)	68.828 ± 3.74	–2.427 ± 4.97 (Insignificant)	2.039 ± 0.03	–0.024 ± 0.04 (Insignificant)
Ammonium sulfate [a] .	33.737 ± 1.73		68.828 ± 3.74		2.039 ± 0.03	
Cowpea	29.513 ± 1.67	4.224 ± 2.404 (Insignificant)	58.703 ± 3.43	10.125 ± 5.074 (Insignificant)	1.988 ± 0.04	0.051 ± 0.05 (Insignificant)
Mungo	36.019 ± 1.68	–2.282 ± 2.411 (Insignificant)	76.154 ± 3.58	–7.326 ± 5.177 (Insignificant)	2.114 ± 0.01	–0.075 ± 0.03 (Insignificant)
Soybean	29.332 ± 0.49	4.405 ± 1.79 (Insignificant)	62.221 ± 1.47	6.607 ± 4.018 (Insignificant)	2.121 ± 0.03	–0.082 ± 0.04 (Insignificant)
Cowpea [b]	29.513 ± 1.67		58.703 ± 3.43		1.988 ± 0.04	
Mungo	36.019 ± 1.68	6.506 ± 2.36 (Insignificant)	76.154 ± 3.58	17.451 ± 4.958 (Insignificant)	2.114 ± 0.01	–0.126 ± 0.04 (Insignificant)
Soybean	29.332 ± 0.49	0.181 ± 1.74 (Insignificant)	62.221 ± 1.47	– 3.418 ± 3.730 (Insignificant)	2.121 ± 0.03	–0.133 ± 0.05 (Insignificant)
Mungo [c]	36.019 ± 1.68		75.154 ± 3.58		2.114 ± 0.01	
Soybean	29.332 ± 0.49	6.687 ± 1.75 (Significant)	62.221 ± 1.47	13.933 ± 3.88 (Significant)	2.121 ± 0.03	–0.007 ± 0.03 (Insignificant)

[a] Ammonium sulfate was used as the basis for comparison.
[b] Cowpea was used as the basis for comparison.
[c] Mungo was used as the basis for comparison.

THE FERTILIZING CONSTITUENTS IN THE SOLID EXCRETA OF SHEEP AND GOATS [1]

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The objects of the present study were to determine (1) the comparative yield of solid excreta voided by sheep and goats, and (2) the comparative amount and value of fertilizing constituents contained therein. Also, the ratio between the yield of solid excreta and live weight of the animals is presented in this paper.

This work was conducted in the College of Agriculture, University of the Philippines. The feeding and management of the animals and the collection of feces were carried out in the Department of Animal Husbandry; the analytical work, in the Department of Agricultural Chemistry. The investigation was begun in December, 1933 and closed in June, 1935, covering a period of 18 months.

ANIMALS

Six head of sheep and six of goats were used. In each class there were five females and one male. The sheep were grade Indians; the goats, of grade Anglo-Nubian blood. All had reached mature size and were selected to represent superior individuals. The average weight of the ewes during the investigation was 28.2 kgm., that of the ram, 49.9 kgm. With the goats, the average weight of the does was 38.0 kgm., and of the wether goat, 37.1 kgm.

MANAGEMENT

All the animals were subjected to about the same feeding methods and management that they had been receiving before being selected for this experiment. In the daytime both sheep and goats were given mixed grasses *ad libitum,* and in the evening the goats received grain-feed consisting of 5 parts of corn, 3 parts of copra meal and 2 parts of rice bran, all by weight. As much as approximately 200 grams of grain were given to each goat daily. The goats had to be fed grains because, as dairy animals, they need a richer feed for a good flow of milk. The forage feed consisted mostly of Para grass

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[1] Experiment Station contribution No. 1119. Read before the Los Baños Biological Club on November 7, 1935. Received for publication November 8, 1935.

(*Panicum barbinode* Trin.) and culape (*Paspalum conjugatum* Berg.).

A feeding crate provided with mangers and stalls was used. There were six compartments in the crate. For one week the goats were housed, fed and watered in the crate; then the sheep were placed in the same stalls and given the same treatment. This alternation was followed throughout the rest of the experimental period. The feces was allowed to accumulate over a tray of woven wire placed under the floor of the stall which was made of wooden slats set about 1.5 cm. apart to allow the feces to drop through. The urine that was passed out went through the open spaces of the floor of the stall and the wire tray into the ground below. To collect feces for chemical analysis a piece of Manila paper was placed in the morning over the wire tray of each stall. As soon as fecal matter was seen on the paper it was collected for chemical analysis, provided, that the paper remained dry showing that no urine had been passed out at the time. No feces contaminated with urine was submitted for chemical analysis. The period during which actual feces collection was made for each of the animals was 60 days.

The collected feces were placed in a clean bottle and immediately sampled for analysis. Portions were taken and analyzed for moisture and nitrogen and converted into ash. The ash obtained was subsequently worked out for the determination of the phosphoric acid, potash and lime it contained. In all chemical determinations, the methods given in the *Official and Tentative Methods of Analysis* (1930) [2] were followed.

DISCUSSION OF RESULTS

Feces production

As may be seen in table 2, the amount of feces produced by the ewes ranged from 443.1 to 952.5 grams daily, the average being 599.9 grams. With the ram, the range was from 635.0 to 907.2 grams, the average being 754.5 grams. The yearly production of feces among the ewes ranged from 191.2 to 293.7 kgm., the average being 219 kgm.; with the ram, the average production was 275.4 kgm.

With the goats, the range in the daily amount of feces voided by the does was from 408.2 to 1179.3 grams. With the male, the daily production ranged from 653.6 to 907.2 grams. The average amount per head voided daily by the does was 674.9 grams; with the wether goat it was 663.7 grams. The average yearly production per head with the females was 246.3 kgm., with the males, 242.3 kgm.

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[2] ANONYMOUS. 1930. Official and tentative methods of analysis. 525 p., 25 fig. Washington D. C.; Association of Official Agricultural Chemists.

Subjecting the daily feces record of the females of both classes of animals to statistical treatment, the mean obtained with the ewes was 602.52 ± 4.76 grams; with the does the mean was 675.26 ± 5.99 grams. With the ram, the mean was 752.96 ± 5.72 grams and with the wether goat, 662.24 ± 12.25. Computing the probable error of the difference between the means of the feces produced by the ewes and does, the difference was found to be significant, the does producing more. With the males, the difference between the means was also significant, the ram yielding more. This ram was an individual of superior size. The coefficient of variation in the amount of feces voided by the ewes was 20.30 ± 0.58, with the does it was 22.81 ± 0.66. With the ram it was 8.83 ± 0.54; with the wether goat the production was more variable, being 21.23 ± 1.36.

Relationship between the live weight and amount of feces voided daily

It may be observed in table 3 that with the ewes the amount of feces passed out per 100 kgm. of the live weight varied from 1.75 kgm. with animal No. 13 to 2.46 kgm. with animal No. 57, the average being 2.15 kgm. The ram's feces per 100 kgm. of its live weight were 1.51 kgm. With the does, the range was from 1.40 kgm. with animal No. 203 to 2.14 kgm. with animal No. 281, the average being 1.80 kgm. The wether goat produced 1.79 kgm. feces per 100 kgm. of its live weight.

FERTILIZING CONSTITUENTS

Table 4 shows the analysis of the fresh feces to be as follows:

Moisture. The average percentage of moisture contained in the feces of sheep was 64.8, the range being from 60.0 to 68.8. Van Slyke (1920) [3] gives the analysis of moisture in the feces of sheep as 60 per cent. With the goats, the average moisture content was 65.1 per cent, the minimum being 58.3 per cent and the maximum, 70.2 per cent.

Nitrogen. The average amount of N_2 contained in the feces of sheep varied from 0.57 to 1.05 per cent, the average for the six animals being 0.75 per cent. The same amount was reported by Van Slyke (1920). In goats, the range was from an average of 0.76 per cent to 1.02 per cent, with an average for the six animals of 0.92

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[3] VAN SLYKE, LUCIUS L. 1920. Fertilizers and crops. XIV ± 734 p., 131 fig. New York: Orange Judd Company.

per cent. The percentage of N_2 in the feces of goats appears to be, with few exceptions, consistently higher than in that of sheep.

Phosphoric acid. The average amount of P_2O_5 in the sheep ranged from 0.84 to 2.02 per cent, the average for the six animals being 1.48 per cent. In Van Slyke's table (1920), the percentage was 0.45. In goats, the variation was from an average of 1.08 to 1.80 per cent, the average for all being 1.51 per cent. Apparently, there is little difference in the P_2O_5 content in the feces of sheep and goats.

Potash. The highest average amount of K_2O found in the feces of sheep was 1.41 per cent, the lowest, 0.35 per cent; the average for the six animals was 0.87 per cent. According to Van Slyke (1920), the average amount of K_2O in the feces of sheep was 0.45 per cent. The minimum average percentage in the goat feces was 0.34 and the maximum was 0.79. The average for the six was 0.56 per cent. Judging by the individual percentage, it appears that the amount of K_2O in the feces of sheep was higher than in that of goats.

Lime. The range in the average percentage of CaO in the feces of sheep was from 0.49 to 1.68, the average being 0.86. In goats, the variation was from 0.42 to 0.80 per cent, the average 0.59. The amount of lime seems to be greater in the feces of sheep than in that of goats.

Quantity and value of fertilizers in feces

In estimating the value of the fertilizing constituents contained in the feces, the following quotations on fertilizers on sale by Menzi and Co. Inc., Manila, as of August 24, 1935, were used. Sulfate of ammonia, containing 20.6 per cent N_2 was quoted at ₱80.00 a ton; sulfate of potash with an average of 44 per cent of K_2O, at ₱120.00 a ton; and superphosphate, averaging 19 per cent of P_2O_5, at ₱45.00 a ton.

Using the results of analysis of the feces as a basis for computation, the quantities of different fertilizers that are contained in the average yearly production of feces by the sheep and the goats are:

ANIMALS	N_2	P_2O_5	K_2O	CaO
	kgm.	*kgm.*	*kgm.*	*kgm.*
Sheep:				
Female	1.64	3.24	1.91	1.88
Male	2.07	4.08	2.40	2.37
Goats:				
Female	2.27	3.72	1.38	1.45
Male	2.23	3.66	1.36	1.43

On the basis of these figures, at the Menzi and Co. prices of fertilizers, the value of the nitrogen, phosphoric acid and potash which may be obtained from each of the animals in one year is as follows:

ANIMALS	N_2	P_2O_5	K_2O
	pesos	*pesos*	*pesos*
Sheep:			
Female	0.64	0.78	0.52
Male	0.81	0.98	0.65
Goats:			
Female	0.89	0.89	0.37
Male	0.87	0.88	0.37

SUMMARY

1. The average daily production of feces of ewes was 599.9 grams a head. With one ram the average was 754.5 grams.

2. The average daily production of feces of does was 674.9 grams a head; of a wether goat, the average was 663.7 grams.

3. The calculated yearly production of feces of the sheep averaged 219 kgm. for the ewe and 275.4 kgm. for the ram. With the goats, the yearly production was 246.3 kgm. for the doe and 242.3 kgm. for the wether goat.

4. The amount of fertilizers which may be derived from the feces of each ewe in one year is: N_2, 1.64 kgm.; P_2O_5, 3.24 kgm.; K_2O, 1.91 kgm.; CaO, 1.88 kgm. From the ram, the production is estimated to be N_2, 2.07 kgm. P_2O_5, 4.08 kgm.; K_2O, 2.40 kgm.; CaO, 2.37 kgm.

5. From each doe the quantity of fertilizers which may be produced in one year is: N_2, 2.27 kgm.; P_2O_5, 3.72 kgm.; K_2O, 1.38 kgm.; CaO, 1.45 kgm. From the male goat, the production would amount to 2.23 kgm. of N_2, 3.66 kgm. of P_2O_5, 1.36 kgm. of K_2O and 1.43 kgm of CaO.

6. The total value of fertilizers contained in one year's production of feces from each ewe is ₱1.94, from the ram ₱2.44, from each doe ₱2.15 and from the male goat ₱2.12.

TABLE 1

Showing the sex, date of birth and average weight of animals used

ANIMALS	SEX	DATE OF BIRTH	AV. WEIGHT
			kgm.
Sheep			
Herd No. 2	Female	November 1, 1921	27.2
” ” 13	Female	December 16, 1924	33.5
” ” 52	Male	March 1, 1929	49.9
” ” 57	Female	November 28, 1929	21.4
” ” 63	Female	September 21, 1930	25.9
” ” 79	Female	December 14, 1931	33 0
Goats			
Herd No. 144	Female	April 23, 1926	34.2
” ” 173	Female	December 30, 1926	35.9
” ” 195	Female	November 12, 1927	44.1
” ” 203	Female	November 19, 1927	43.5
” ” 281	Female	March 28, 1930	32.5
” ” 304	Male (Castrated)	January 13, 1931	37.1

TABLE 2

Showing the amount of feces voided by sheep and goats

ANIMAL	AMOUNT VOIDED IN 60 DAYS	RANGE IN AMOUNT VOIDED DAILY	AV. DAILY PRODUCTION	CALCULATED YEARLY PRODUCTION
Herd No.	*grams*	*grams*	*grams*	*kgm.*
Sheep				
2	31,427.9	453.6– 725.7	523.8	191.2
13	35,142.1	443.1– 771.1	585.7	213.8
52	45,268.2	635.0– 907.2	754.5	275.4
57	31,614.3	453.6– 816.5	526.9	192.3
63	35,147.3	453.6– 816.5	585.8	213.8
79	46,629.3	635.0– 952.5	777.2	283.7
Goats				
144	36,377.4	408.2– 816.5	606.3	221.3
173	41,458.3	453.6– 907.2	691.0	252.2
195	46,493.1	453.6–1179.3	774.9	282.8
203	36,413.6	453.6– 907.2	606.9	221.5
281	41,730.0	453.6– 997.9	695.5	253.9
304	39,824.9	453.6– 907.2	663.7	242.3

TABLE 3

Showing the relationship between the live weight of sheep and goats and the amount of feces voided daily

SHEEP	AV. LIVE WEIGHT	AVERAGE AMOUNT OF FECES VOIDED DAILY	AMOUNT OF FECES VOIDED DAILY PER 100 KGM. LIVE WEIGHT	GOATS	AV. LIVE WEIGHT	AVERAGE AMOUNT OF FECES VOIDED DAILY	AMOUNT OF FECES VOIDED DAILY PER 100 KGM. LIVE WEIGHT
Herd No.	*kgm.*	*grams*	*kgm.*	*Herd No.*	*kgm.*	*grams*	*kgm.*
2	27.2	523.8	1.93	144	34.2	606.3	1.77
13	33.5	585.7	1.75	173	35.9	691.0	1.92
52	49.9	754.5	1.51	195	44.1	774.9	1.76
57	21.4	526.9	2.46	203	43.5	606.9	1.40
63	25.9	585.8	2.26	281	32.5	695.5	2.14
79	33.0	777.2	2.36	304	37.1	663.7	1.79

TABLE 4

Showing the average analysis of feces of sheep and goats.

ANIMALS	NUMBER OF SAMPLES	MOISTURE	N_2	P_2O_5	K_2O	CaO
Herd No.		*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Sheep						
2	5	60.0	1.05	1.90	1.41	1.68
13	5	67.1	0.69	1.18	0.55	0.64
52	5	61.1	0.84	1.45	0.62	0.63
57	5	63.7	0.72	1.48	0.87	0.86
63	6	68.8	0.57	2.02	0.94	0.86
79	5	68.0	0.65	0.84	0.35	0.49
	Average	64.8	0.75	1.48	0.87	0.86
Goats						
144	6	60.2	1.01	1.64	0.55	0.69
173	5	67.5	0.84	1.59	0.47	0.42
195	5	66.2	0.96	1.08	0.34	0.44
203	5	58.3	1.02	1.80	0.79	0.80
281	5	70.2	0.92	1.69	0.57	0.54
304	5	67.4	0.76	1.27	0.65	0.67
	Average	65.1	0.92	1.51	0.56	0.59

A STUDY ON THE FORMATION AND NITROGEN CONTENT OF ROOT TUBERCLES OF COWPEA

MANUEL L. DINGLASAN

WITH ONE TEXT FIGURE

The cowpea, *Vigna sinensis* (Linn.) Savi ex Hassk, besides its use as a vegetable, is recognized as being of value as a means of adding nitrogen to the soil. It is often grown in the field to be plowed under for green manure. It is a valuable green manure because on its roots nodules are formed in which nitrogen-fixing bacteria *Rhizobium leguminosarum* Frank live. Lipman (1919) estimated the amount of nitrogen that is added to the soil in the United States from legumes and found it to be equivalent to more than one million and a half tons a year. Thus, the large sum of money which otherwise might be invested in the purchase of nitrogenous commercial fertilizers in that country is saved. A similar saving might also be realized by farmers in the Philippines if the growing of legumes for green manuring were guided by experience and by a sufficient knowledge on the subject. In conducting the study here reported the objective was always in mind—the determination of the influences upon the degree or extent of nodulation and fixation of atmospheric nitrogen in tubercles by certain natural soil conditions or by certain artificial or cultural treatments.

REVIEW OF LITERATURE

As early as 1838 Boussingault, cited by Bear (1929), demonstrated that cowpeas had the power to increase the nitrogen content of the soil in which they were growing. It was, however, erroneously believed that the cowpeas could fix atmospheric nitrogen by the aid of their foliage.

The use of legumes as green manure has been found not only to increase the total soil nitrogen but also to improve the physical condition of the soil through the addition of organic matter. Lipman and Blair (1921) found in cylinder experiments that commercial

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[1] Thesis presented for graduation, 1934, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture, No. 499; Experiment Station contribution No. 1120. Prepared in the Department of Plant Physiology under the direction of Dr. Rafael B. Espino.

nitrogenous fertilizers were inferior to leguminous green manures in maintaining the fertility of the soil.

There are a few records of the amounts of nitrogen fixed by individual plants. Hopkins (1904) found that the average fixation by cowpeas was 1.29 grams of nitrogen per plant. Alway and Pinckney (1910) noted a fixation of 0.004 gram of nitrogen per plant of alfalfa in the field, and Wright (1925) obtained a fixation of approximately 0.4 gram of nitrogen per plant of soybean.

The influence on nodulation of salts and commercial fertilizers has been studied also. Marchal (1901), as cited by Giöbel (1926), worked with peas in culture solutions and found that nitrates of potassium, sodium, calcium and ammonium prevented the formation of nodules. On the other hand, phosphates of calcium and of magnesium favored the formation of nodules. Also, in general, Wilson (1917) found chlorides and phosphates of calcium stimulated, while sulfates, nitrates and ammonia containing salts depressed nodule formation of soybean.

Eichinger (1913) found that sodium nitrate prevented nodule formation of soybeans and cowpeas, but superphosphate stimulated it. Rantenberg and Kuhn (1864), Schindler (1885), Prasmonsky (1891). Nobbe and Hiltner (1899), Prucha (1915) and Wilson (1917), as cited by Giöbel (1926), working with various legumes in solution-culture experiments, all observed that soluble nitrogen reduced in numbers, or completely inhibited the formation of nodules. Wohltmann and Bergené (1902) also cited by Giöbel in studies on the influence on nodule formation of soil composition obtained similar results. Van Slyke (1920) found that when supplied with soluble nitrogen compounds the nitrogen fixing bacteria failed to make use of atmospheric nitrogen. Ewart (1915) as cited by Giöbel reported that sodium nitrate and potassium nitrate when applied to soil at the rate of 95 pounds per acre had no depressing effect on the production of nodules by beans.

Wohltmann and Bergené (1902) as cited by Giöbel (1926) studied the effect upon nodule production of various types of soil, ranging from clay rich in organic matter to sand poor in organic matter. They found that in general the organic matter in the soil exerted no harmful effects on the nodules. They found, too, that in a soil containing 14 per cent of humus and 0.3 per cent of nitrogen no nodules developed. Schindler (1885) as cited by Giöbel noted that more nodules were produced in sandy soil than in clay soils, and explained that this difference was probably due to the better conditions of aëration in the sandy soil.

OBJECT OF THIS STUDY

The object of the present study was to study the formation and the nitrogen content of root-tubercles of cowpea, as influenced by (*a*) different types of soil, (*b*) cultivation, (*c*) sterilization of soil (partial and thorough), (*d*) different amount of horse manure, and (*e*) commercial fertilizers.

TIME AND PLACE

This study was carried out in pots in the experimental yard of the Department of Plant Physiology during the period from July 19, 1932 to September 22, 1933.

MATERIALS, METHOD AND RESULTS

The plant

In this study a variety of cowpea with creamy white seed was used. This variety was chosen on account of its earliness in maturing and its erectness. The plants were started from seeds which were planted directly in earthen pots, three seeds to a pot. When the young plants were about a week old they were thinned to one plant in a pot.

The soil types [2]

The soils used were (*a*) sand, (*b*) Lipa clay loam, (*c*) subsoil of Lipa clay loam (mixture of Lipa clay loam and weathered tuff). (*b*) gravelly loam (roadside), (*c*) gravelly loam (creek), (*f*) light gravelly loam, (*g*) heavy clay loam, and (*h*) bay loam. These soils were collected from several places: the *sand*, from Laguna de Bay shore near the barrio Mayondon, Los Baños; the *Lipa clay loam*, from the experimental plots of the Department of Plant Physiology; the *subsoil of Lipa clay loam*, from an excavation made near the Department of Plant Pathology; the *gravelly loam* (roadside), from the canals along the road near the Department of Agricultural Engineering; the *gravelly loam* (creek), from the banks of the Molawin Creek; the *light gravelly loam*, from a corn field near the Los Baños Stone Quarry; the *heavy clay loam*, a very sticky soil, from an uncultivated area covered with sedge near the U. S. N. Radio

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[2] The soil types here used were identified by Dr. Robert L. Pendleton of the Soils Department.

Station; the *Bay loam*, very near the marshy place along the shore of Laguna de Bay near the U. S. N. Radio Station, uncultivated and a natural habitat of species of plants, such as, *Typha, Bacopa, Fimbristilis*. Before using, each of these soil types was air dried and afterward pulverized, sieved, and thoroughly mixed before the required amounts were put in pots.

Horse manure and commercial fertilizers used

The horse manure was partly decayed. It was obtained from a stable in San Antonio, Los Baños. It was first dried in the sun then pulverized, sieved and thoroughly mixed. It was added to the soil in pots in varying amounts.

The fertilizers used were (*a*) ammonium sulfate containing about 20.6 per cent N, (*b*) potassium sulfate containing 48 to 50 per cent K_2O, and (*c*) superphosphate containing about 18 to 20 per cent P_2O_5.

The fertilizers were applied at the rate of one ton per hectare when used singly. But, when two of the fertilizers were added to the same culture, the rate of application became two tons per hectare, when three were added, three tons, because the amount of each fertilizer added to the culture remained the same whether it was used as single or as mixed.

Sterilization of soil

In some of the cultures, partially and thoroughly sterilized soils were used. A sufficient quantity of the *Lipa clay loam* soil was placed on a galvanized iron sheet placed over an open fire. To effect a thorough sterilization, the soil was heated to red hot for some time. The partial sterilization was made by sufficiently heating the soil but not at red heat. These treatments were given to the soil in order to kill all the bacteria in the thoroughly sterilized culture and to kill some of the bacteria in that partially sterilized.

The bacteria

Microscopic studies of the bacteria found in nodules produced from certain cultures were made. Fresh nodules were crushed on glass slides and the bacteria among the crushed materials were examined under both a compound microscope and under an oil-immersion objective. No drawing was made but it was observed that apparently only one type of bacteria was seen in the specimens although they were obtained from nodules produced from cultures that received different treatments. The bacteria were rod-shaped with one to three *knots* in each.

Care in harvesting

The plants in each set of cultures were harvested at the time of flowering. In removing the plant from each pot, the pot was turned upside down with the palm of a hand supporting it and the soil. After a little shaking the mass of soil together with the plant would come out. Then, to obtain the roots and the nodules, the ball of soil was placed under a water faucet and the flow of the water was carefully regulated so as not to detach the nodules from the roots of the plant. All the nodules that were accidentally detached were collected.

Representative nodules were measured lengthwise with a micro-caliper. Then, the nodules were detached from the roots and those that were obtained from each culture were placed in a paper envelope ready for drying in the oven.

The nodules removed, the plants were exposed to the sun for the initial drying. When sufficiently dried, the tops were separated from the roots and separately wrapped in paper, ready for drying in the oven to constant weight.

Analyses of nodules for nitrogen

The nitrogen content of the nodules produced in the different cultures were determined. The modified Kjeldahl (1930) method was employed in the determination. As a rule, the nitrogen content of the nodules obtained from each culture was analyzed in triplicate samples. In a few cases where the nodules were limited only one or two samples were analyzed. The analytical work was done in the Department of Plant Physiology with the assistance of Mr. Julian A. Banzon of the Department of Agricultural Chemistry. He saw that the apparatus was properly set up and the proper calculations made. A few check analyses were made by Mr. Lauro Ynalvez, analyst of the same department. It was found that the results he obtained from a mass of nodules were quite similar to those found by the writer, when the samples were taken from the same lot or stock of nodules. It is, therefore, to be expected that the data obtained on nitrogen content were reliably determined.

The cultures and general results

Five main sets of cultures were tried. Inasmuch as the methods employed in studying the different problems were different from one another, it was deemed convenient to consider them separately.

Problem 1. To determine the comparative production of nodules and of nitrogen by cowpea plants grown in soil of different sources or types.

In an attempt to solve this problem the following culture media, each pot containing about 7,160 cc. of soil, were employed. The soil samples used although of the *same volume* had different weights, (air dry) as shown below:

Culture I contained 9 kgm. of sand.
Culture II contained 7.5 kgm. of Lipa clay loam.
Culture III contained 7.5 kgm. of subsoil of Lipa clay loam.
Culture IV contained 7.5 kgm. of gravelly loam (roadside).
Culture V contained 7.5 kgm. gravelly loam (creek).
Culture VI contained 7.5 kgm. of light gravelly loam.
Culture VII contained 9 kgm. of heavy clay loam.
Culture VIII contained 6 kgm. of bay loam.

These differences of weights of the soil samples are given here to show the comparative weights of samples of the different types of soil used.

Two similar sets of cultures were employed. The first set was run in six replications, and the second set in five replications. The first set of cultures was started on July 19, 1932 and the plants were harvested on September 30, 1932. The second set of cultures was started on November 17, 1932 and the plants were harvested on January 31, 1933. The average data obtained under different criteria employed are shown in table 1. The plants that yielded the data under column *a* were photographed two days before they were harvested (see fig. 1).

Problem 2. To determine the comparative production of nodules and of nitrogen by cowpea plants grown in pots as influenced by cultivation.

This experiment consisted of two sets of cultures with only two types of cultures in each set. However, each culture type included in the first set was replicated ten times; while the two culture types in the second set had five replications each. One type of culture in each set was cultivated weekly, that is, the soil near the surface in each pot was loosened with a pointed stick and the weeds removed. The cultures representing the other type were only weeded. The weeds were pulled up with as little disturbance of the soil as possible. Care was taken not to disturb the nodules.

The first set of cultures was started on November 17, 1932 and the plants were harvested on January 31, 1933. The identical set of cultures was started on June 22, 1933 and the plants were harvested on September 5, 1933. The average of experimental data are shown in table 2.

Problem 3. To determine the comparative production of nodules and of nitrogen by cowpea plants grown in pots containing unsterilized, partially sterilized and thoroughly sterilized Lipa clay loam soil.

To work out this problem the following culture media were tested.

Cultures I and IV each contained 7.5 kgm. of *thoroughly* sterilized soil.
Cultures II and V each contained 7.5 kgm. of *partially* sterilized soil.
Cultures III and VI each contained 7.5 kgm. of *unsterilized* soil.
Cultures I, II, and III received boiled water while cultures IV, V and VI received tap water.

Two similar sets of cultures were tried. Each culture was grown to a cowpea plant. The first set of cultures was started on February 2, 1933 and the plants were harvested on April 22, 1933. The second set of cultures was started on June 22, 1933 and the plants were harvested on September 5, 1933. The average experimental data obtained are shown in table 3.

Problem 4. To determine the comparative production of nodules and of nitrogen by cowpea plants grown in pots containing Lipa clay loam soil to which was added horse manure in varying amounts.

To work out this problem, two similar sets of cultures were tried. Each set consisted of six cultures in five replications each. The proportions of the soil with the manure were as follows:

Culture I, 1/2 part horse manure and 1/2 part of soil.
Culture II, 3/8 part horse manure and 5/8 part of soil.
Culture III, 2/8 part horse manure and 6/8 part of soil.
Culture IV, 1/8 part horse manure and 7/8 part of soil.
Culture V, 1/16 part horse manure and 15/16 part of soil.
Culture VI no horse manure was added.

The proportions were by volumes, not by weight. The first set of cultures was started on February 2, 1933 and the plants were harvested on April 11, 1933. The second set of cultures was started on June 22, 1933 and harvested on September 2, 1933. The average of experimental data obtained from both sets of cultures are given in table 4.

Problem 5. To determine the comparative production of nodules and of nitrogen by cowpea plants grown in pots containing subsoil of Lipa clay loam to which was added different commercial fertilizers.

To study this problem the following culture media were employed:

Culture I, contained 7.5 kgm. of soil and 3.98 grams of ammonium sulfate.
Culture II, contained 7.5 kgm. of soil and 3.98 grams of potassium sulfate.
Culture III, contained 7.5 kgm. of soil and 3.98 grams of superphosphate of lime.
Culture IV, contained 7.5 kgm. of soil and 3.98 grams each of ammonium sulfate, potassium sulfate and superphosphate of lime.
Culture V, contained 7.5 kgm. of soil and 3.98 grams each of ammonium sulfate and superphosphate of lime.
Culture VI, contained 7.5 kgm. of soil and 3.98 grams each of superphosphate of lime and potassium sulfate.
Culture VII, contained 7.5 kgm. of soil and 3.98 grams each of ammonium sulfate and potassium sulfate.
Culture VIII, contained 7.5 kgm. of soil and no fertilizer (control).

Two similar sets of cultures were employed, each set consisted of eight cultures. Each culture was tried in five replications and in each culture a cowpea plant was grown. The first set of cultures was started on February 2, 1933 and the plants were harvested on April 15, 1933. The second set of cultures was started on June 22, 1933, and the plants were harvested on September 2, 1933. The average of experimental data that was obtained from the two sets of cultures are given in table 5.

Criteria of results and the experimental data gathered

The criteria employed as the basis of comparing the results brought about by the different treatments given to the cultures in this study were (*a*) dry weight of tops, (*b*) dry weight of roots, (*c*) dry weight of nodules, (*d*) number of nodules, (*e*) per cent nitrogen in nodules, and (*f*) total nitrogen in nodules. The data that were gathered under these criteria were obtained as follows:

Dry weight of tops. At the time of harvest the tops were severed from their roots. The tops and the roots produced in each culture were first dried in the sun, and afterwards thoroughly dried in an electric oven. When dry, the weights of the tops obtained from the different cultures were determined.

Dry weight of roots. Soon after the nodules were detached from the roots, they were dried first in the sun and afterwards in an electric oven to constant weight. Then, the weights of the roots obtained from different cultures were separately determined.

Number, length and dry weight of nodules. The length of each of the fifty nodules was measured with a micro-caliper. They were measured while they were still attached to the roots. Then, the nodules were detached from the roots of each plant, counted and wrapped in paper. They were dried to constant weight in an electric oven and then the weights of the nodules produced from each culture was determined.

Per cent nitrogen in nodule. Samples of nodules produced from the different cultures were analyzed. For this analysis, the modified Kjeldahl (1930) method of determining total nitrogen was followed. The formula employed in determining the nitrogen content of nodules is as follows:

$$\text{Per cent nitrogen} = \frac{(AN_1 - BN_2)\,0.014}{C} \times 100$$

Where A is the volume of standard acid used; B, the volume of standard alkali titrated; N_1, normality of standard acid and N_2, normality of standard alkali. C, the weight in gram of sample analyzed, 0.014, gram of nitrogen per cc., equivalent to 1 cc. of a normal solution of acid.

The average data thus obtained are shown in tables 1 to 5. For purposes of comparison, the data on averages have been compiled and are shown in table 6. They were reduced to their *relative values*, that is, the highest per cent of nitrogen was arbitrarily taken as 100, and the other data in the table were reduced to their respective *relative values* on the basis of this assumed value.

Total nitrogen in nodules. The total nitrogen in nodules obtained from each culture was determined. It was determined by multiplying the *dry weight of the nodules* from each culture by the corresponding *average per cent of nitrogen* found. The averages of the data obtained are shown in tables 1 to 5.

DISCUSSION OF RESULTS

As indicated by the title and the objects, this study was undertaken primarily to determine the production of nodules and of nitrogen in the nodules. Therefore, the data on the *dry weight of tops* and on the *dry weight of roots* are here presented only to show the states of development of the vegetative organs of the plants and, also, in a rather rough way, the relation between the *yield of tops* and the *yield of roots* on the one hand and the *yields of nodules and of nitrogen* on the other. No biometrical computations were made to show accurately the presence or absence of correlation. However, the influences upon the production of nodules and the storage of nitrogen in them by certain cultural treatments seem to be quite apparent.

Nitrogen content of nodules produced by cowpeas

In different soil types. The nitrogen content of nodules seemed to vary in the different cultures not only in term of gross quantity but also in per cent contained in samples. The gross quantity will be referred to later, but as may be seen in table 6 the nitrogen contents of samples seem to have been influenced by soil types as well as by certain treatments.

Comparing the effects of the soil types used on the nitrogen-content of nodules, it may be seen in table 6 that the *heavy clay loam*, the *light gravelly loam*, and the *sand* produced nodules that were relatively low in nitrogen-content. The average precentages of nitrogen contained in the nodules produced in these three kinds of soil were only 3.51, 4.57, and 4.64 per cent, respectively. The rest of the soil types tested produced nodules containing more than 5 per cent (average) of nitrogen. In other words, the *Lipa clay loam*, and its *subsoil*, and the two gravelly loams (one from the roadside, and the other from the creek) were fairly conducive to the production of a relatively high percentage of nitrogen in the nodules.

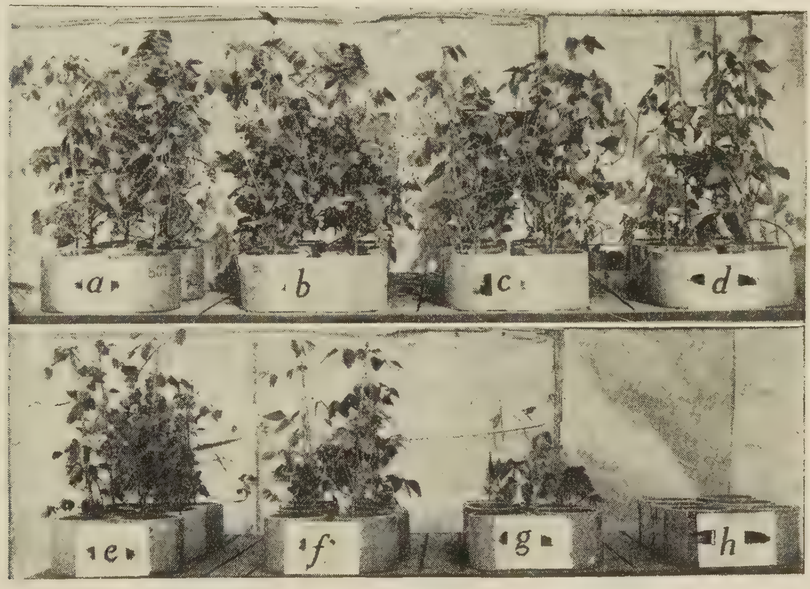

Fig. 1.—Cowpea plants grown in different types of soil. *a*, Lipa clay loam, *b*, subsoil of Lipa clay loam, *c*, gravelly loam (roadside). *d*, gravelly loam (creek). *e*, light gravelly loam, *f*, sand, *g*, heavy clay loam and *h*, Bay loam. The plants were planted on July 19, 1932 and harvested on September 30, 1932.

With and without cultivation. The data in table 6 seemed to show also that *cultivation,* which is a means of improving the air condition in the soil and promoting the development of the root system, caused a slight increase of the nitrogen content of the nodules as compared with those produced from the *uncultivated* cultures. The difference was so slight, however, that further tests should be made before a definite conclusion can be made.

Effects of sterilization of soil by heat. Sterilization of the *Lipa clay loam* soil by heat, whether thorough or only partial, seemed to decrease the nitrogen content of the nodules. This contention was borne out by the data in table 6. In no thoroughly or partially sterilized culture was the nitrogen content of the nodules found to be more than 5 per cent. On the other hand, the two unsterilized cultures produced nodules, the one containing 5.27 per cent and the other, 5.26 per cent of nitrogen. Therefore, sterilization of the soil by heat appeared to be harmful to symbiotic nitrogen fixation. This was probably due to the decrease in the number of symbiotic nitrogen fixing organisms occasioned by heat and the destruction of the organic matter in the soil. Or, if the bacteria were not harmed at all the reduction in the nitrogen content in the nodules might have been due, according to Waksman and Starkey (1923), to the accumulation of ammonia in the partially sterilized soil, a condition found in the present study (see table 6) to be not conducive to nitrogen fixation.

Influence of addition of horse manure. Table 6 also shows that the addition of horse manure to the *Lipa clay loam* soil seemed to be favorable to nitrogen fixation. However, the difference between the results obtained from this treatment and these obtained from the soil alone was so slight that it was deemed advisable to consider it as negligible.

Effects of fertilizers. The data in table 6 also show that the addition of commercial fertilizers, singly or in certain combinations, to the subsoil of *Lipa clay loam* in pots had certain influences on the fixation of nitrogen in the nodules. Except culture (*f*) in table 6 to which both superphosphate and potassium sulfate were added, all the cultures that received ammonium sulfate produced root-tubercles containing nitrogen less than those from the control culture (subsoil alone) or less than those that received either potassium sulfate or superphosphate. Except in the ammonium sulfate culture, however, the decrease in nitrogen content below that of the control was so little that the difference may be considered as negligible.

The ammonium sulfate culture produced nitrogen as low as 4.4 per cent, the lowest in the lot. On the other hand, the potassium sulfate culture and the superphosphate cultures appeared to be quite favorable to nitrogen fixation. The former produced nodules containing 5.84 per cent of nitrogen, and the latter contained 5.62 per cent of nitrogen.

Additional comparison. When the data in table 6 were converted to their respective *relative values*, it was found that the latter range from 100 as the highest value to 60 as the lowest value. Therefore, the difference was sufficiently large to make comparison quite significant. It might then be possible to arbitrarily select the cultures that might be considered as *high* yielders of nitrogen and those that might be considered as the *low* yielders of nitrogen. For purposes of this comparison, the cultures that received *relative values* of 95 or above were marked H-1, H-2, etc., in table 6, and were arbitrarily considered as *high* yielders of nitrogen. On the other hand, those cultures that received *relative values* below 90 were marked L-1, L-2, etc., to denote that they were *low* yielders of nitrogen. Inspection of table 6 revealed the fact that, in the descending order, *Lipa clay loam* fertilized with potassium sulfate, *gravelly loam* (creek), *subsoil of Lipa clay loam, Lipa clay loam* fertilized with superphosphate, and *Lipa clay loam* alone were favorable to nitrogen fixation in the nodules of cowpea. Similarly, the low yielders of nitrogen, again in the descending order, were the *heavy clay loam* the two thoroughly-sterilized *Lipa clay loam,* the *light gravelly loam,* and the *sand.*

Production of nodules and of nitrogen by cowpea plants grown in different soils

Inspection of the data in table 1, showed that cultures I, V, VI, VII, and VIII were not quite suitable for the best growth and development of the cowpea plant, the yields of tops and of roots from these cultures being relatively low. In fact, culture VIII which contained *Bay loam* soil was not able to sustain the life of the plant. For, soon after germination, the young plants died. And, although the other cultures, I, V, VI, and VII, were able to bring the plants to maturity, these had not only relatively low yields of tops and of roots but also were low in the production of nodules, both in point of number and in dry weight. Moreover, the total nitrogen content of the nodules produced from these cultures was also relatively low.

On the other hand, cultures II, III, and IV appear not only conducive to a relatively high production of the vegetative organs of the plant but also relatively high in the production of nodules and in total nitrogen in the nodules. However, when the two highest data under each criterion or column were arbitrarily selected (see table 1 indicated by H's), it revealed the fact that the highest yielder of top and of root (see culture II and especially culture III) did not produce the highest yield of nodules and of nitrogen. It revealed also the fact that the highest yields of nodules, both in point of number and in dry weight, and the highest yields of total nitrogen were obtained from culture IV, which did not produce exceptionally high yields of tops and roots. Therefore, it may be safe to conclude that production of nodules and of total nitrogen was not necessarily dependant upon the apparent vigor of the plant. In closing, it should, however, be said that as far as the production of nodules and of their nitrogen content was concerned, *gravelly loam* (roadside) was the best, and the *Lipa clay loam* was the next best, (see cultures IV and II, respectively).

Effects of cultivation and non-cultivation on nodulation and nitrogen content of nodules

It may be seen in table 2 that culture I, which received weekly cultivation whenever the soil was not too wet, was better than culture II which was not cultivated at all. The difference was in term of the yield data under the different criteria used, and the external appearance of the plants. However, the difference was so slight that it might be attributed to experimental error, hence, negligible.

Soil sterilization harmful to nodule and nitrogen production

Table 3 showed that under the criteria here used, and excepting culture VI b roots, cultures III and VI were better than the rest of the cultures. Culture I, which had soil thoroughly sterilized by heat produced the lowest yields of tops, roots, nodules, and of total nitrogen and as far as the production of nodules and of nitrogen, culture IV, in which the soil was also thoroughly sterilized by heat, was decidedly poor. Cultures II and V were also poor yielders of nodules and of nitrogen. Therefore, thorough sterilization of the *Lipa clay loam* soil by heat was most harmful, and, the partial sterilization the next most harmful to the production of nodules and of nitrogen in the nodules by the cowpea plant. The decrease in nodulation and in the production of total nitrogen in the nodules was probably due to the complete or partial killing of the bacteria of nitrogen fixation or the ignition of the organic substances during the thorough and partial sterilization of the soil, or due to both causes. Cultures III and VI, with unsterilized soil gave the best results, in term of dry weights of tops and of roots as well as in the number and the dry weights of the nodules, and in the nitrogen content of the nodules, the latter being as much as 0.0349 gram of nitrogen as compared with the highest yield obtained from the thorough sterilization, 0.0046 gram of nitrogen per plant. As many as 403 nodules weighing 0.663 gram (dry weight) were produced from the unsterilized cultures, but the best result obtained from the sterilized cultures was only 76 nodules with a dry weight of 0.101 gram.

Production of nodules and of nitrogen as influenced by addition of horse manure

For purposes of comparison the two highest yields under each criterion of results employed were arbitrarily selected and indicated by H's in table 4. Likewise, the two lowest yields were arbitrarily selected and are indicated also in table 4 by L's.

It has now become apparent that culture II received the maximum number of H's, and culture VI, the maximum number of L's. Therefore, under the criteria of results employed, culture II was the best, and culture VI, the poorest. Culture II had in the culture medium 5 parts of the *Lipa clay loam* soil and 3 parts of horse manure; while culture VI was the control culture and did not receive any manure. It was also shown in table 4 that under the criteria employed any of the manured cultures gave higher yield than the control culture. Therefore, it appeared that the addition of horse manure to the *Lipa clay loam* soil was always beneficial not only to the cowpea plant but also to the production of nodules and of total nitrogen in the nodules. However, as shown in table 4, the beneficial effects of the manure had certain limits. For, as the amount of the manure was increased or decreased from the best amount found, there was a corresponding decrease in yields of tops and of roots, and a corresponding decrease in the yields of nodules and of their nitrogen content. This condition was particularly true when the amount of the manure was decreased.

Effects of commercial fertilizers upon the production of nodules and of nitrogen by cowpea plants

Table 5 shows that culture I gave a relatively high yield of top, but in nodules and nitrogen production it was the lowest. It may also be seen in this table that the control (culture VIII), being unfertilized, produced the lowest yield of tops and of roots but it was not the lowest in nodules and nitrogen production. Cultures I and

VII, which received ammonium sulfate and both ammonium sulfate and potassium sulfate, respectively, gave relatively low yields of nodules and of total nitrogen, and in no case higher than the control. The harmful effects upon nodule formation and nitrogen fixation in the nodules brought about by the addition of the nitrogenous fertilizer used in this study appeared to be in accord with the findings of Eichinger (1918) who reported that sodium nitrate, which is also a nitrogenous fertilizer, prevented nodule formation of soybeans and cowpeas. Wilson (1917) also observed similar harmful effects upon nodule formation of soybeans when nitrate and ammonia containing salts were added to the soil. But, all the cultures that received either superphosphate of lime, potassium sulfate, or the combinations of these two fertilizers were in no instance inferior to the control in the production of nodules and of nitrogen. Not much difference in the production of nodules and of nitrogen was observed between culture IV, which received ammonium sulfate, superphosphate and potassium sulfate, and the control. This case seemed to show that the apparent inhibitory effects of ammonium sulfate was somewhat counteracted by the addition to the soil of either superphosphate or potassium sulfate, or of both fertilizers. It might also be said that the apparent favorable influence on nodulation and nitrogen fixation by potassium sulfate, superphosphate or of both fertilizers when added to soil in pots was destroyed or interfered with by the addition of ammonium sulfate to the mixture. The apparent beneficial effects upon nodules and nitrogen production that were observed in this study when superphosphate was added to the soil seemed to confirm the findings of Wilson (1917) and of several investigators cited by Giöbel (1926). On the other hand, the beneficial effects upon nodulation and the production of nitrogen in the nodules by potassium sulfate, seemed to be confirmed by the researches of Perkins (1924) and opposed to those of Marchal (1901) and of Flammand (1904) cited by Giöbel.

SUMMARY AND CONCLUSIONS

1. This study dealt with the formation and the nitrogen content of root nodules of cowpea, *Vigna sinensis* (Linn.) Savi ex Hassk in pots as influenced by kinds of soil and certain cultural treatments.

2. The nitrogen fixing bacteria in the nodules appeared to be only one kind, rod-shaped with from one to three knots or segments each.

3. The *heavy clay loam*, the *light gravelly loam*, and the *sand* produced nodules with relatively low nitrogen content. The *Lipa*

clay loam, its *subsoil,* and two *gravelly loams* (from roadside and from creek) were conducive to production of nodules with relatively high nitrogen content.

4. Cultivation caused a slight increase in nodule production and nitrogen content of nodules; but, the increase was so little that further tests should be made before a definite conclusion can be safely drawn.

5. Sterilization of *Lipa clay loam* by heat, whether partial or thorough, appeared to be harmful to nodule production and the fixation of nitrogen in the nodules. Unsterilized soil produced as much as 5.27 per cent of nitrogen.

6. Addition of horse manure to *Lipa clay loam* soil was slightly favorable to nitrogen fixation in the nodules. But, the increase was so little that it was deemed advisable to consider it as negligible. The addition of the manure to the soil, however, was found beneficial not only to the cowpea plant but also to the production of nodules and of *total* nitrogen in the nodules.

7. Addition of ammonium sulfate to the cultures containing subsoil of *Lipa clay loam* produced nodules containing less nitrogen than those from the *control* (subsoil only), and less than those that received either potassium sulfate or superphosphate.

8. In the descending order, *Lipa clay loam* fertilized with potassium sulfate, *gravelly loam* (creek), subsoil of *Lipa clay loam, Lipa clay loam* alone or fertilized with superphosphate were favorable to nitrogen fixation in the nodules of cowpea. The low yielders of nitrogen were the *heavy clay loam,* the sterilized *Lipa clay loam,* the *light gravelly loam,* and the *sand.*

9. The cowpea plant did not grow in the *bay loam* soil. Soon after germination, the young plants died.

10. The production of nodules and of total nitrogen in the nodules was not dependent upon the apparent vigor of the plant. In the production of nodules, (in number and in dry weight), and of nitrogen content, *gravelly loam* (roadside) was the best, and the *Lipa clay loam,* the next best.

11. Sterilization of *Lipa clay loam* soil, whether partial or complete, was harmful as it caused a decrease in the percentage of nitrogen in the nodules and in gross production of nodules and hence, of nitrogen. Nodules of an average plant grown in the unsterilized soil gave 0.0349 gram of nitrogen; in sterilized soil 0.0046 gram. As many as 403 nodules, weighing 0.663 gram (dry weight)

were produced from the unsterilized cultures, but the best result obtained from the sterilized culture was only 76 nodules with a dry weight of 0.101 gram.

12. Cultures that received either ammonium sulfate or a combination of ammonium sulfate and potassium sulfate gave relatively low yields of nodules and of total nitrogen, and in no case higher than the control (not fertilized). On the other hand, cultures that received either superphosphate or potassium sulfate or both fertilizers were better than the control.

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TABLE 1

Average amounts of nitrogen in nodules produced by cowpea, Vigna sinensis (Linn.) Savi ex Hassk grown in pots containing different types of soil

CULTURE NO. AND SOIL TYPE USED	DRY WEIGHT[a] OF						NUMBER OF NODULES		PER CENT N IN NODULES[b]	TOTAL N IN NODULES	
	tops		roots		nodules						
	a	b	a	b	a	b	a	b		a	b
	grams	*grams*	*grams*	*grams*	*grams*	*grams*				*gram*	*gram*
I. Sand	7.09	6.17	1.31	1.35	0.184	0.221	95	87	4.64	0.0085	0.0103
II. Lipa clay loam	21.94 H	14.70 H	2.34 H	2.24 H	0.831 H	0.867 H	570 H	566 H	5.33	0.0444 H	0.0462 H
III. Mixture of clay loam and weathered tuff (subsoil of Lipa clay loam)	20.34 H	12.43 H	2.48 H	2.33 H	0.336	0.391	265	223	5.72 H	0.0192	0.0220
IV. Gravelly loam ..... (roadside)	[c] 10.87	11.38	1.90	1.97	1.271 H	1.263 H	648 H	616 H	5.03	0.0639 H	0.0635 H
V. Gravelly loam (creek)	[c] 7.94	7.25	1.70	1.39	0.173	0.113	78	66	5.82 H	0.0101	0.0066
VI. Light gravelly loam .	7.02	5.97	1.09	0.99	0.064	0.081	52	46	4.57	0.0030	0.0037
VII. Heavy clay loam ...	4.57	4.79	1.04	1.06	0.039	0.072	40	34	3.51	0.0014	0.0031
VIII. Bay loam (mostly organic matter	Germinated but all soon died.										

[a] The data under *a* and *b* were not averaged because they were obtained from two cultures conducted at different time. *a* was planted July 19, 1932 and harvested September 30, 1932, *b* was planted November 17, 1932 and harvested January 31, 1933.

[b] Samples of nodules from set of culture *a* were analyzed.

[c] Some of the leaves were lost, blown away by the wind during the initial drying in the sun.

TABLE 2

Average amounts of nitrogen in nodules produced by cowpea, Vigna sinensis (Linn.) Savi ex Hassk grown in pots as influenced by cultivation

CULTURE NO. AND TREATMENTS MADE	DRY WEIGHT[a] OF						NUMBER OF NODULES		PER CENT N IN NODULES	TOTAL N IN NODULES	
	tops		roots		nodules						
	a	b	a	b	a	b	a	b		a	b
	grams	*grams*	*grams*	*grams*	*gram*	*gram*				*gram*	*gram*
I. Cultivated ..	4.97	29.45	1.96	4.09	0.660	0.703	420	455	5.39	0.0349	0.0372
II. Uncultivated	4.33	26.38	1.76	3.88	0.639	0.608	386	416	5.21	0.0333	0.0317

[a] *a* and *b* are different sets of cultures, *a* was planted November 17, 1932 and harvested January 31, 1933, *b* was planted June 22, 1933 and harvested September 5, 1933.

TABLE 3

Average amounts of nitrogen in nodules produced by cowpea, Vigna sinensis (Linn.) Savi ex Hassk grown in pots containing unsterilized, partially sterilized and thoroughly sterilized soil

CULTURE NO. AND TREATMENTS MADE	DRY WEIGHT[a] OF						NUMBER OF NODULES		PER CENT N IN NODULES	TOTAL N IN NODULES	
	tops		roots		nodules						
	a	b	a	b	a	b	a	b		a	b
	grams	*grams*	*grams*	*grams*	*grams*	*grams*				*gram*	*gram*
I. Thoroughly sterilized	5.69	9.47	2.03	2.37	0.034	0.023	24	18	4.17	0.0014	0.0010
II. Partially sterilized .	6.06	12.38	2.27	2.62	0.169	0.166	113	133	4.70	0.0084	0.0082
III. Unsterilized	6.93	20.32	2.69	4.06	0.489	0.485	361	327	5.27	0.0258	0.0256
IV. Thoroughly sterilized	6.50	12.68	2.05	2.53	0.101	0.048	76	39	4.56	0.0046	0.0022
V. Partially sterilized .	6.61	14.59	2.15	4.12	0.167	0.185	116	143	4.98	0.0086	0.0096
VI. Unsterilized	7.01	19.92	2.72	4.10	0.663	0.535	403	357	5.26	0.0349	0.0281

[a] *a* and *b* are different sets of cultures, *a* was planted February 2, 1933 and harvested April 22, 1933; *b* was planted June 22, 1933 and harvested September 5, 1933. Cultures I, II and III received boiled water, while cultures IV, V and VI received tap water.

TABLE 4

Average amounts of nitrogen in nodules produced by cowpea, Vigna sinensis (Linn.) Savi ex Hassk grown in pots containing Lipa clay loam soil to which was added horse manure in varying amounts

CULTURE NO. AND TREATMENTS MADE	DRY WEIGHT[a] OF						NUMBER OF NODULES		PER CENT N IN NODULES	TOTAL N IN NODULES	
	tops		roots		nodules						
	a	b	a	b	a	b	a	b		a	b
	grams	*grams*	*grams*	*grams*	*gram*	*gram*				*gram*	*gram*
I. 1/2—Clay loam .... 1/2—manure	6.18	20.59	2.00	3.66	0.693 H	0.640	482 H	446 H	5.34	0.0370 H	0.0342
II. 5/8—Clay loam .... 3/8—manure	6.46 H	23.67 H	2.07 H	4.28 H	0.744 H	0.774 H	486 H	511 H	5.40 H	0.0402 H	0.0418 H
III. 6/8—Clay loam .... 2/8—manure	6.30 H	23.03 H	2.12 H	3.96 H	0.607	0.643 H	477	429	5.38 H	0.0327	0.0346 H
IV. 7/8—Clay loam .... 1/8—manure	4.99	18.39	1.91	3.45	0.575	0.521	445 L	368	5.27 L	0.0303	0.0274 L
V. 15/16—Clay loam .. 1/16—manure	4.63 L	17.55 L	1.89 L	3.31 L	0.556 L	0.519 L	458	351 L	5.27 L	0.0293 L	0.0274 L
VI. Clay loam alone .... (control)	4.40 L	14.32 L	1.73 L	2.43 L	0.520 L	0.449 L	353 L	209 L	5.18 L	0.0269 L	0.0233 L

[a] *a* and *b* are different sets of cultures; *a* was planted February 2, 1933 and harvested April 11, 1933; *b* was planted June 22, 1933 and harvested September 2, 1933.

TABLE 5

Average amounts of nitrogen in nodules produced by cowpea, Vigna sinensis (Linn.) Savi ex Hassk grown in pots containing subsoil of Lipa clay loam to which different commercial fertilizers were added

CULTURE NO. AND FERTILIZERS ADDED	DRY WEIGHT[a] OF						NUMBER OF NODULES		PER CENT N IN NODULES	TOTAL N IN NODULES	
	tops		roots		nodules						
	a	b	a	b	a	b	a	b		a	b
	grams	*grams*	*grams*	*grams*	*gram*	*gram*				*gram*	*gram*
I. N	7.08 H	39.15 H	2.10 H	5.58	0.082	0.107	66 L	82 L	4.40 L	0.0036 L	0.0047 L
II. P	6.04	31.87	1.95	4.75	0.787 H	0.935 H	448 H	613 H	5.84 H	0.0459 H	0.0546 H
III. K	7.06 H	37.48 H	1.93 L	4.60 L	0.392	0.489 H	299	327	5.62 H	0.0221	0.0274 H
IV. N-P-K	6.71	32.06	2.10 H	6.65 H	0.396	0.304 L	256	217	5.51	0.0218	0.0168
V. N-P	5.81	29.75	2.05	5.15	0.334	0.308	224	237	5.38	0.0180	0.0166
VI. P-K	5.72 L	27.10 L	2.11 H	5.85 H	0.488 H	0.484	314 H	351 H	5.31	0.0259 H	0.0256
VII. N-K	5.83	30.69	2.05	5.30	0.211 L	0.199 L	134 L	153 L	5.20 L	0.0110 L	0.0103 L
VIII. Control	5.68 L	20.25 L	1.89 L	4.05 L	0.290 L	0.309	192	206	5.59	0.0162	0.0173

N = NH_4-sulfate; P = double superphosphate; K = K-sulfate.

[a] *a* and *b* are entirely different set of cultures; *a* was planted February 2, 1933 and harvested April 15, 1933; *b* was planted June 22, 1933 and harvested September 2, 1933.

TABLE 6

Average percentages of nitrogen and their relative values

TREATMENTS GIVEN TO CULTURE MEDIA	AV. PER CENT OF NITROGEN	RELATIVE VALUES [a]
Sand	4.64	79L-6
Lipa clay loam	5.33	91
Subsoil of Lipa clay loam (mixture of clay loam and weathered tuff)	5.72	97H-3
Gravelly loam (roadside)	5.03	85
Gravelly loam (creek)	5.82	99H-2
Light gravelly loam	4.57	78L-4
Heavy clay loam	3.51	60L-1
Lipa clay loam		
(a) with cultivation	5.39	92
(b) without cultivation	5.21	89
Lipa clay loam		
(a) thoroughly sterilized; boiled water	4.17	71L-2
(b) partially sterilized; boiled water	4.70	80
(c) unsterilized; boiled water	5.27	90
(d) thoroughly sterilized; tap water	4.56	78L-5
(e) partially sterilized; tap water	4.98	85
(f) unsterilized; tap water	5.26	90
Lipa clay loam		
(a) 1/2 soil + 1/2 horse manure	5.34	91
(b) 5/8 soil + 3/8 horse manure	5.40	92
(c) 6/8 soil + 2/8 horse manure	5.38	91
(d) 7/8 soil + 1/8 horse manure	5.27	90
(e) 15/16 soil + 1/16 horse manure	5.27	90
(f) soil alone	5.18	88
Lipa clay loam (subsoil)		
(a) soil + ammonium sulfate	4.40	75L-3
(b) soil + potassium sulfate	5.84	100H-1
(c) soil + superphosphate	5.62	96H-4
(d) soil + ammonium sulfate + potassium sulfate + superphosphate	5.51	94
(e) soil + ammonium sulfate + superphosphate	5.38	91
(f) soil + superphosphate + potassium sulfate	5.31	90
(g) soil + ammonium sulfate + potassium sulfate	5.20	88
(h) soil alone	5.59	95H-5

[a] Appendix tables 6, 7, 8, 9 and 10 from which the data were compiled are not published.

STUDIES ON THE PHYSICAL QUALITIES OF THE HEN'S EGG: IV. CHANGES IN CANDLING APPEARANCE OF LOS BAÑOS CANTONESE EGGS AS AFFECTED BY AGE[1]

F. M. FRONDA AND D. D. CLEMENTE

WITH ONE TEXT FIGURE AND THREE CHARTS

In commercial grading of eggs, candling is the most common method used. In this process, the size of the air cell is considered as one of the principal factors in determining the quality of the egg. Observations made by Stewart, Gans and Sharp (1932) showed that there was a small but definite relation between the width of the air cell and interior quality of the eggs.

Fronda and Clemente (1934) made observations on one hundred new-laid Los Baños Cantonese eggs and reported that the mean height of the air cell was 0.140 ± 0.0081 centimeters. In their studies on the influence of seasonal changes on the physical qualities of new-laid Los Baños Cantonese eggs, Fronda, Clemente and Basio (1935) concluded that the air cells of eggs laid during the dry, hot months are smaller than those of eggs laid during the wet months.

It is a matter of common observation that as the egg ages, the air space increases in size owing to evaporation of water from the liquid contents of the egg. The amount of evaporation depends very largely upon the age of the egg and the atmospheric temperature and humidity at which the egg has been kept (Fronda and Clemente, 1936).

The extent to which the air cell of an egg increases in size when held for varying lengths of time under ordinary laboratory conditions has not yet been studied. Studies along this line should be of value. The observations reported in this paper were made in order to furnish the buyer of eggs a possible guide in approximating the age of the eggs before he buys them.

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[1] Part of the expenses incurred in this study were paid from a research grant by the Philippine Poultry Association. The figures presented in this paper were taken from data contained in the thesis presented by D. D. Clemente for graduation, March, 1933, with the degree of Bachelor of Science in Agriculture, No. 448; Experiment Station contribution No. 1121. Received for publication October 3, 1935.

PLAN OF THE STUDY

These studies were conducted in the Poultry Laboratory, Department of Animal Husbandry, College of Agriculture, Los Baños from November, 1931 to October, 1932. One hundred and eighty-five new-laid Los Baños Cantonese eggs from the flocks of the College were set aside each month for observation. After measuring the height and the diameter of each egg, the initial air cell was traced with a lead pencil by candling in the evening of the day of collection. The eggs were then placed in shallow boxes 50 centimeters long, 35 centimeters wide, and 10 centimeters deep, each box being well padded with excelsior. The eggs were turned once a day in transferring them from one box to another.

The height and diameter of the air cell of ten eggs were determined within twenty-four hours after they were laid. Every three days after the collection was made up to the ninety-ninth day, five eggs taken at random were candled with an electric candler. As an egg was candled the air cell was traced with a lead pencil in the same manner as was done when the egg was new-laid. From these tracings the height and the diameter of the air cell were determined (fig. 1). Observations were made also on the change of color and the porosity of the egg shell.

RESULTS AND DISCUSSIONS

Appearance of the shell

It was only in rare cases in the 2,200 eggs examined that new-laid Los Baños Cantonese eggs with visible pores were found. By ocular inspection and without using any color standard it was noted that there were no abrupt distinct changes on the color of the shells. It was observed that as the eggs became older the shells became shiny, possibly due to the loss of the cuticle with increase in age. This observation confirms Fronda's (1928) statement that old eggs that have been subjected to much handling show shiny surfaces.

Except in a few cases newly laid eggs were found to have no visible pores. As the eggs became older, pores began to appear. These visible pores were darkish little spots, the size of a pin head, usually located near the air cell. A similar observation was also reported by Holst and Almquist (1931) who made more detailed studies on this particular subject.

Candling appearance

A new-laid egg when seen through a candler had a small air space. Although no particular attention was given to the variation of the candling appearance of new-laid eggs from month to month, some observations were made on the candling characteristics of the eggs studied at different ages.

Three stages of decomposition were recognized in this study. Jenkins (1918) and Pennington, Jenkins and Betts (1918) stated that *mixed rot* was the term applied to the first stage; this was followed by *white rot;* and lastly by *black rot.* These authorities stated that mixed rot is the characteristic of an egg with the white thin and unevenly streaked with yellow, and the yolk is partially mixed with the white and may contain whitish streaks. White rot is the characteristic of an egg having the white and the yolk more or less completely mixed and the egg has a stale or sour odor. Benjamin's

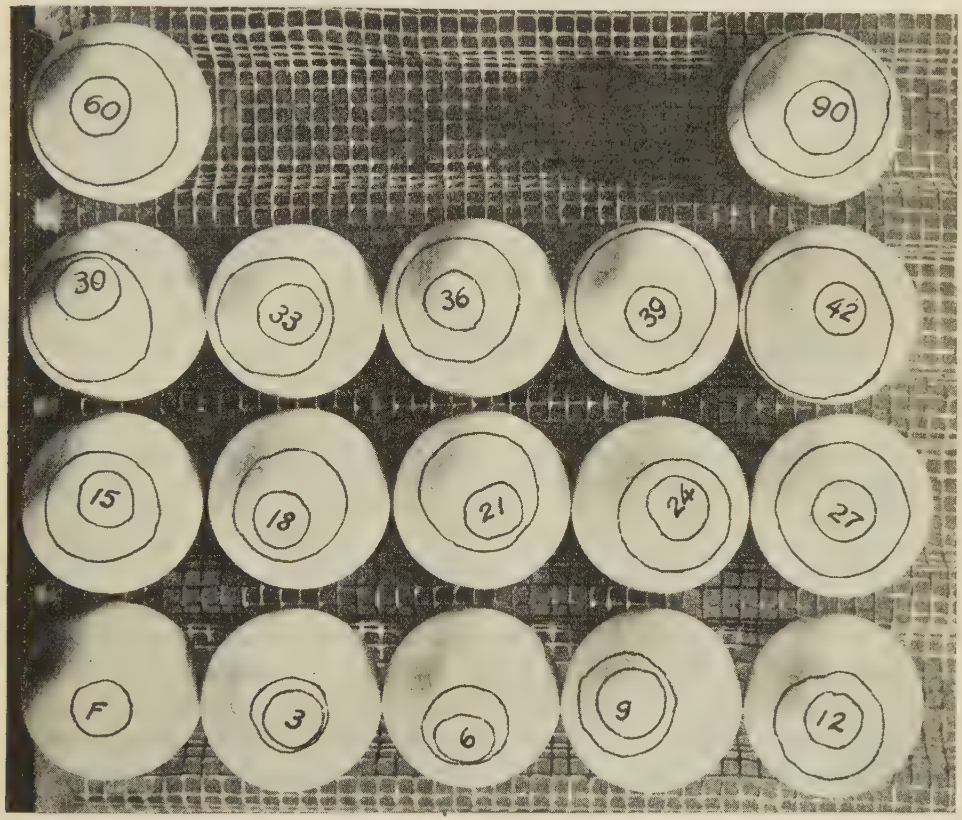

Fig. 1.—Eggs of different ages, shown by number on eggs, new-laid to ninety days, showing tracings of the initial air cells (inner circle) and of the air cells at the time of candling (outer circle). The egg at the lower left corner (marked "F") is a new-laid egg.

(1914) definition of black rot was followed. He states that the contents of such eggs had an offensive odor of sulfur. The yolk is of an oily black color, usually yellow particles of sulfur are floating on the surface. The yolk contents are usually, but not necessarily, mixed with the albumen. The albumen is very watery, often being similar in appearance to sour whey.

The eggs with whole yolks were easy to distinguish when the eggs were still fresh, the hardest age being when the eggs candled were around one month old. At this age, the eggs with whole yolks were sometimes mistaken for mixed rots. It might have been possible also that at this time some of the eggs with whole yolks when candled, the yolks were broken in opening. The mixed rots were hard to determine from the white rots when the eggs were observed at two months old. At this age, the number of mixed rots and white rots were nearly the same, showing the transition period of the mixed rots to white rots. Black rots were easy to determine by candling, except in some cases, where the eggs upon candling were classed as white rots but upon opening were found to have dirty yellow content which, according to Pennington, Jenkins and Betts (1918), may be another form of black rot. The eggs with partly dried yolks were hard to distinguish from the white rots. The egg with slightly stuck yolk was harder to identify by candling than when the yolk was heavily stuck.

The air cell

The term "initial air cell" as used in this paper means the air cell of each egg when candled within 24 hours after it was laid. The air cell generally develops at the large end of the egg by the two shell membranes separating and the space produced filling with air (Slocum, 1928). There were variations observed in this study in the location of the air cells. The air cells of a few eggs were found to be at the sides and in six cases out of the 2,220 eggs candled, the air cells were found located at the small end of the egg. The air cells of some eggs were difficult to locate, either because of the thickness of the shell or, as was the case among some of the old eggs, the air cell was broken.

The height of the air cell. The average height of the initial air cells of the eggs studied was 0.142 centimeter (see table 1). Fronda and Clemente (1934) reported that the new-laid Los Baños Cantonese eggs that they studied had a mean air cell height of 0.140 ± 0.0012 centimeter.

Table 1 gives the averages of the heights of the air cells of eggs at different ages held during the different months of the year. Careful study of the figures given in this table will reveal the fact that the longer the eggs were held, irrespective of the month of the year during which they were held, the higher the air cells became. It may be noted, however, that the rate of increase of the height of the air cell differs in eggs that were held during different months. It is plain that the height of the air cells of the eggs held during the dry months increased more rapidly than that of eggs held during the moist months (see chart 1). This increase is fairly regular during the first month of age in all sets.

The following instances may be pointed out to illustrate this statement. After nine days of holding, the eggs held from January to June had higher air cells than those held during the other months, in spite of the fact that the heights of the initial air cells of the former were less than those of the latter. After nine days of holding, the average air cell height of all the eggs studied was observed to be 0.369 centimeter, and the range was from 0.27 centimeter in the eggs held in September to 0.46 centimeter in those held in June. The average height of the air cells of nine-day old eggs held from January to June was observed to be 0.405 centimeter; that of eggs held from July to December was only 0.333 centimeter. The average increase of the height of the air cells of eggs laid from January to June was 0.268 centimeter, or 195.62 per cent; that of those from July to December was only 0.186 centimeter, or only 126.62 per cent. Chart 1 shows clearly the differences in the rate of increase in the height of air cells.

The diameter of the air cell. The average initial diameter of the air cells of the eggs studied was 1.314 centimeters. This figure is almost the same as that reported by Fronda and Clemente (1934) who observed that the mean diameter of new-laid Los Baños Cantonese eggs was 1.323 ± 0.0081 centimeters. As with the height of the air cell, the diameter increased as the eggs were held longer. The rate of increase in the diameter of the air cell was more rapid during the first two weeks of holding than during the latter periods (see table 2 and fig. 1).

By reference to table 2, it may also be seen that although the initial diameter of the air cell is apparently not as much influenced by the season as the height, a fact also reported by Fronda, Clemente and Basio (1935), the rate of increase in the diameter, like that of the height, was observed to be more rapid during the dry months than during the moist months. Chart 2 illustrates this point very plainly. During the first six months of the year, the diameter of the air cell of Los Baños Cantonese eggs that had been held for nine days averaged 2.177 centimeters, ranging from 2.00 centimeters in the January set to 2.32 centimeters in the June set. This represents an average increase of 0.862 centimeter from the average initial diameter of 1.315 centimeters, or 65.55 per cent. On the other hand, the diameter of the air cells of eggs held for nine days in July to

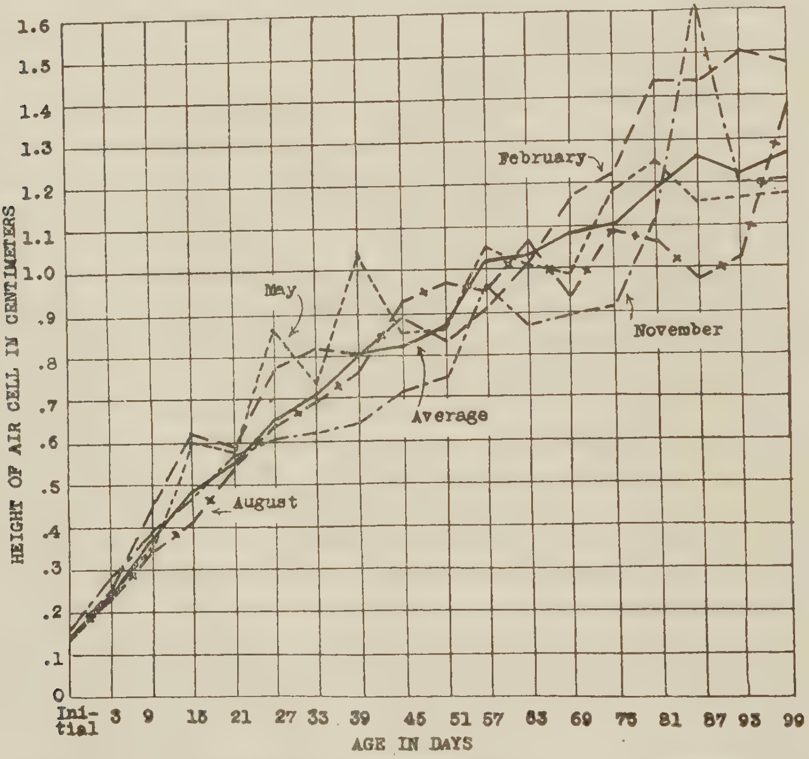

Chart 1.—Curves showing the rate of increase of the height of air cells of eggs held during different months. The average for the year is represented by solid line.

December, averaged only 2.003 centimeters, ranging from 1.82 centimeters in the September set to only 2.11 centimeters in both the July and the August sets. In this case, the average increase was only 0.693 centimeter from the average initial diameter of 1.310 centimeters, or an increase of only 52.90 per cent.

The air cell index. Fronda and Clemente (1934) determined the air cell index of 100 new-laid Los Baños Cantonese eggs and found it to be 0.108 ± 0.006. This figure was obtained by dividing the height of the air cell by its diameter. In the present study, the average air cell index of the 2,200 new-laid eggs studied was also 0.108. As the eggs were held longer, the air cell index increased also. The average air cell index of Los Baños Cantonese eggs held

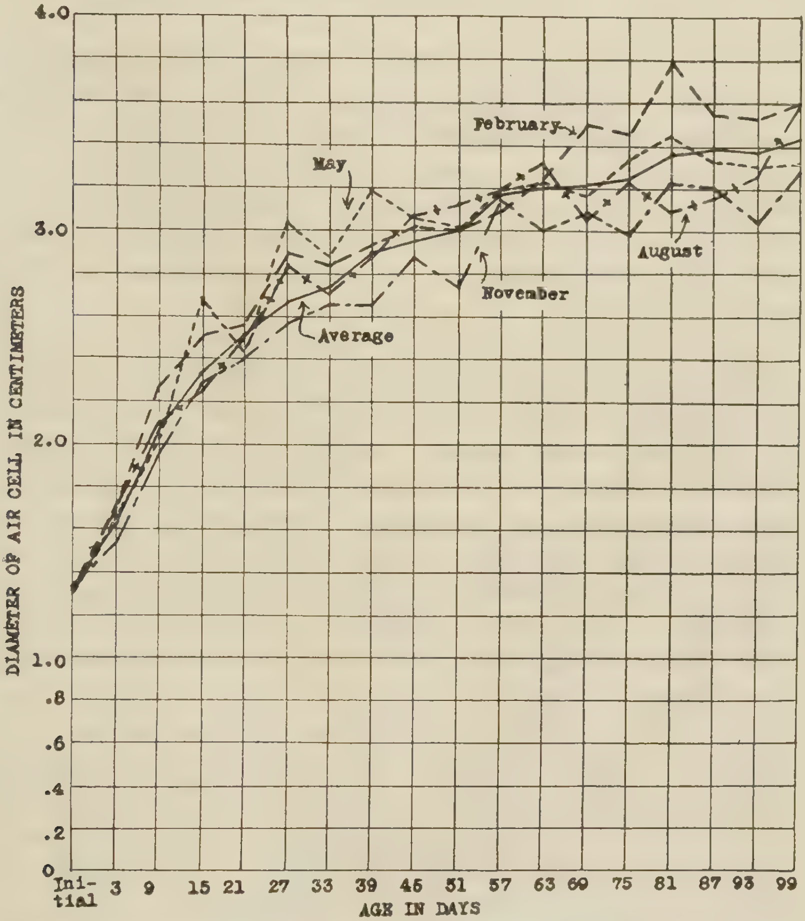

Chart 2.—Curves showing the rate of increase of the diameter of air cells of eggs held during different months. The average for the year is represented by solid line.

in different months and at different ages may be seen in table 3 and also graphically presented in chart 3.

By reference to table 3, it may be seen that the air cell index increased from 0.108 in the new-laid eggs to 0.370 in the 99-day-old eggs. The increase in the air cell index was gradual and fairly regular, but in all cases, it was observed that the increase was more rapid during the earlier ages of the eggs than during the latter. Of course, the larger the air cell, the greater was the index. Exceptions, however, occurred because the eggs studied varied in shape. An elongated egg will have a deep air cell, but the diameter of the air cell is narrow. This particular egg has an air cell index that is high.

The air cell and the size and form of the egg. Realizing that the size and form of an egg has something to do with the height and width of its air cell, an attempt was made by Fronda and Clemente (1934) to overcome these factors by determining the air cell height-egg height and the air cell diameter-egg diameter percentages. The averages of the figures obtained from eggs set in the different months and at different ages are given in table 3 and graphically presented in chart 3.

As may be seen by reference to table 3 and to chart 3, both the air cell height-egg height and the air cell diameter-egg diameter percentages followed the same tendency, that is, as the eggs became older, the air cell diameter-egg diameter and the air cell height-egg height percentages correspondingly increased. The increase in the air cell diameter-egg diameter percentage was, however, greater than that of the air cell height-egg height percentage. The air cell height-egg height percentages increased from 2.78 in the new-laid eggs to 25.00 in the 99-day-old eggs, while the increase in the air cell diameter-egg diameter percentage was from 33.84 in the new-laid to 90.14 in the 99-day-old eggs.

Going over the figures obtained from eggs held during the different months, it was observed that in both cases, the percentages of those held during the dry months increased more rapidly than those held during the moist months. For instance, the air cell height-egg height percentage of the 15-day-old eggs held in November increased from 3.13 to 9.13; in February, it increased from 2.72 to 11.92; from 2.52 to 12.15 in April; from 2.68 to 7.95 in July; and from 2.52 to only 7.88 in October. A similar tendency was observed in the air cell height-egg height percentages of eggs held at different ages. The air cell diameter-egg diameter percentage of 15-day-old eggs increased from 34.20 to 61.21 in November; from 33.85 to 64.77 in February; from 32.64 to 66.67 in April; from 33.68 to 56.67 in July; and from 33.94 to 57.94 in October. The increase was, of course, due to the changes in the size of the air cell. The lower the figure, the smaller the air cell, and the higher the figure, the larger the air cell.

The air cell as an index of age. From the foregoing data it may be seen that the height of the air cell, the diameter of the air cell, the air cell index, the air cell height-egg height percentage and the air cell diameter-egg diameter percentage may be used in approximately determining the age of an egg held under ordinary room conditions. In order, however, to determine the practicability of each method it was found necessary to treat statistically the data obtained from each of these determinations. For this purpose, only the data obtained at intervals of 15 days from the new-laid egg to the

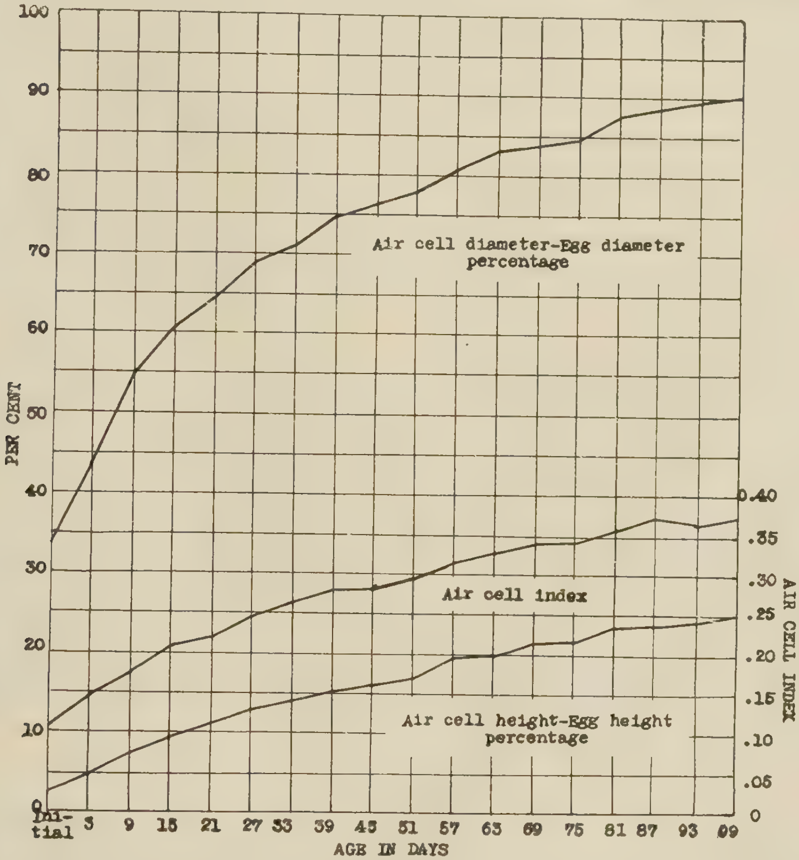

Chart 3.—Curves showing the average air cell index, air cell height—egg height percentage and the air cell diameter—egg diameter percentage of eggs of different ages and held during the different months of the year.

90-day-old egg were considered. The figures obtained are given in table 4.

A study of the data given in table 4 will show that the different characteristics studied may be used in determining the age from new-laid to 90-day-old eggs. It may be observed that the characters that varied most were the air cell height and the air cell height-egg height percentage, in both of which the coefficients of variability of the means from 15-to 90-day-old eggs were over 10 per cent. It was thought that the character that varied the least would be the best guide in determining the age of an egg. By examination of the figures in table 4, however, it may be seen that the diameter of the air cell and the air cell diameter-egg diameter percentage are the least variable, the coefficient of variability of the first character being only around 5 per cent, and that of the second, even less than 5 per cent. For commercial purposes, therefore, the use of these characters seems to be more accurate than the others studied, but these are rather difficult to determine.

The air cell index appears to be only slightly more variable than the air cell diameter and the air cell diameter-egg diameter percentage, but much less variable than the air cell height-egg height percentage. For practical purposes, therefore, this character appears to be the best to use for it involves only dividing the height of the air cell by its diameter. For Los Baños Cantonese eggs, the average air cell index of eggs of different ages and held during the different months as given in table I may be used as a guide, provided that proper allowance is made for the season during which the eggs are held, the air cell index being higher in those held during the dry months than in those held during the wet months.

SUMMARY OF CONCLUSIONS

One hundred and eighty-five new-laid Los Baños Cantonese eggs were held under ordinary laboratory conditions each month from November, 1931 to October, 1932 or a total of 2,200 eggs. The height and diameter of the air cells of ten of these eggs were determined within twenty-four hours after they were laid. Every three days thereafter to the ninety-ninth day, five eggs taken at random were candled and the air cells studied. The results obtained from the study may be summarized as follows:

1. It was noted that no distinct changes occurred in the color of the shells, but these became shiny as the eggs became older.

2. When candled, the eggs with whole yolks were easy to distinguish when the eggs were still fresh. It was difficult to determine by candling the quality of the eggs when they were around one month old.

3. It was observed that the longer the eggs were held, irrespective of the month of the year, the higher the air cells became.

4. The height of the air cells of the eggs held during the dry months was observed to increase more rapidly than that of eggs held during the moist months.

5. As with the height of the air cell, the diameter increased as the eggs were held longer. The rate of increase in the diameter of the air cell was more rapid during the first two weeks of holding than during the later periods.

6. It was also observed that, as with the height of the air cell, the rate of increase in the diameter was more rapid during the dry months than during the moist months.

7. It was noted that as the eggs were held longer, the air cell index increased. The increase in the air cell index was gradual and fairly regular, but in all cases, it was observed that the increase was more rapid during the earlier ages of the eggs than during the later.

8. As the eggs became older, both the air cell diameter-egg diameter and the air cell height-egg height percentages increased. The increase in the air cell diameter-egg diameter percentage was, however, greater than that of the air cell height-egg height percentage.

9. Both the air cell height-egg height and the air cell diameter-egg diameter percentages increased more rapidly in eggs held during the dry months than in those held during the moist months.

10. The results obtained in this study show that the height of the air cell, the diameter of the air cell, the air cell index, the air cell height-egg height percentage and the air cell diameter-egg diameter percentage may be used in approximately determining the age of an egg held under ordinary room conditions.

11. The increase in the diameter of the air cell and the air cell diameter-egg diameter percentage were observed to be the least variable of the characters observed, but their use for commercial purposes is not recommended as they are rather difficult to determine.

12. For practical purposes, although slightly more variable than the air cell diameter and air cell diameter-egg diameter percentage, the use of the air cell index appears to be the best for it involves only dividing the height of the air cell by its diameter.

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TABLE 1

Showing the averages of the air cell heights of eggs at different ages held during different months

AGE OF EGGS	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	AVERAGE
days	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
Newly laid	0.16	0.15	0.16	0.14	0.14	0.12	0.13	0.13	0.14	0.15	0.14	0.14	0.142
3	0.28	0.24	0.22	0.25	0.23	0.18	0.24	0.22	0.25	0.23	0.25	0.24	0.236
6	0.33	0.29	0.28	0.29	0.37	0.35	0.25	0.40	0.27	0.36	0.25	0.31	0.312
9	0.39	0.29	0.32	0.44	0.43	0.43	0.35	0.46	0.33	0.35	0.27	0.37	0.369
12	0.45	0.21	0.38	0.48	0.40	0.52	0.46	0.43	0.39	0.46	0.40	0.44	0.435
15	0.47	0.43	0.44	0.62	0.45	0.64	0.60	0.51	0.41	0.42	0.39	0.42	0.483
18	0.53	0.45	0.46	0.69	0.50	0.68	0.62	0.67	0.45	0.51	0.51	0.40	0.539
21	0.57	0.49	0.48	0.59	0.58	0.66	0.58	0.61	0.48	0.54	0.53	0.55	0.550
24	0.54	0.59	0.56	0.68	0.67	0.70	0.65	0.58	0.74	0.66	0.57	0.47	0.617
27	0.61	0.63	0.57	0.77	0.68	0.76	0.86	0.63	0.57	0.64	0.51	0.54	0.647
30	0.66	0.67	0.63	0.76	0.65	0.85	0.85	0.68	0.66	0.71	0.61	0.53	0.688
33	0.62	0.71	0.61	0.82	0.79	0.93	0.73	0.68	0.77	0.69	0.66	0.56	0.714
36	0.68	0.73	0.76	0.85	0.83	0.96	0.87	0.71	0.76	0.72	0.68	0.69	0.770
39	0.64	0.73	0.67	0.81	0.97	1.03	1.04	0.79	0.70	0.76	0.69	0.77	0.800
42	0.69	0.79	0.74	0.90	0.91	0.99	0.76	0.73	0.81	0.78	0.62	0.67	0.782
45	0.71	0.67	0.79	0.89	0.87	0.88	0.83	0.91	0.89	0.93	0.69	0.77	0.820
48	0.66	0.83	0.85	0.89	0.99	1.20	0.88	1.06	0.86	0.85	0.72	0.96	0.896
51	0.74	0.75	0.88	0.83	0.97	1.14	0.86	0.80	0.85	0.97	0.84	0.76	0.866
54	0.82	0.78	0.93	0.99	1.12	1.20	1.02	0.97	0.95	0.86	0.80	0.94	0.948
57	0.96	0.89	0.99	0.91	1.17	1.29	1.05	1.13	1.05	0.95	0.80	1.02	1.017
60	0.82	0.98	0.97	0.96	1.11	1.21	1.00	1.07	1.00	0.93	0.85	0.81	0.976
63	0.87	0.84	1.16	1.01	1.33	1.18	1.01	0.92	1.04	1.06	0.83	1.11	1.030
66	0.90	0.91	1.05	1.03	1.30	1.14	1.08	1.01	1.02	0.91	1.06	0.87	1.023
69	0.89	0.92	1.14	1.16	1.35	1.17	0.98	1.18	0.99	0.93	0.99	1.24	1.078
72	0.97	1.10	1.26	1.14	1.31	1.07	1.11	0.96	1.08	1.18	1.04	0.93	1.096
75	0.91	1.09	1.21	1.22	1.26	1.26	1.17	1.21	1.01	1.09	0.94	0.84	1.101
78	0.96	1.07	1.22	1.13	1.37	1.32	1.11	1.16	1.07	1.01	1.03	0.99	1.120
81	1.11	1.24	1.08	1.43	1.43	1.35	1.25	1.17	1.04	1.06	1.10	1.07	1.194
84	1.11	1.26	0.99	1.33	1.36	1.48	1.09	1.39	1.30	0.99	1.14	1.28	1.227
87	1.62	1.23	1.48	1.43	1.41	1.16	1.15	1.34	1.20	0.97	1.10	1.03	1.260
90	1.43	1.28	1.27	1.54	1.18	1.27	1.23	1.33	1.03	1.03	1.18	1.07	1.237
93	1.20	1.25	1.23	1.50	1.40	1.39	1.16	1.12	1.13	1.03	1.13	1.11	1.221
96	1.42	1.21	1.72	1.48	1.42	1.39	1.35	1.46	1.13	1.24	1.36	1.37	1.379
99	1.21	1.41	1.03	1.47	1.41	1.16	1.17	1.24	1.24	1.38	1.21	1.31	1.270

TABLE 2

Showing the averages of the air cell diameters of eggs at different ages held during different months

AGE OF EGGS	NOV.	DEC.	JAN.	FEB.	MARCH	APRIL	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	AVERAGE
days	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
Newly laid	1.34	1.29	1.38	1.30	1.33	1.27	1.31	1.29	1.29	1.34	1.30	1.30	1.314
3	1.53	1.76	1.30	1.66	1.75	1.44	1.63	1.66	1.74	1.70	1.71	1.82	1.642
6	1.72	1.85	1.77	1.82	2.16	2.09	1.91	1.99	1.91	2.04	1.78	1.99	1.919
9	1.95	1.95	2.00	2.25	2.21	2.24	2.04	2.32	2.11	2.11	1.82	2.08	2.090
12	2.23	2.13	2.12	2.28	2.14	2.49	2.42	2.27	2.19	2.26	2.13	2.27	2.244
15	2.28	2.12	2.32	2.50	2.26	2.62	2.65	2.45	2.21	2.26	2.14	2.23	2.337
18	2.24	2.74	2.24	2.64	2.49	2.73	2.61	2.74	2.36	2.40	2.36	2.34	2.491
21	2.39	2.56	2.29	2.55	2.52	2.74	2.43	2.62	2.46	2.49	2.55	2.48	2.507
24	2.51	2.42	2.58	2.64	2.65	2.75	2.66	2.51	2.77	2.73	2.52	2.45	2.599
27	2.56	2.48	2.43	2.90	2.74	2.78	3.03	2.64	2.56	2.84	2.39	2.65	2.667
30	2.56	2.50	2.60	2.76	2.80	2.92	3.03	2.76	2.72	2.85	2.52	2.49	2.709
33	2.64	2.74	2.46	2.83	2.81	2.98	2.87	2.73	2.86	2.70	2.59	2.60	2.734
36	2.71	2.71	2.65	2.85	3.01	3.02	3.07	2.82	2.77	2.84	2.74	2.70	2.824
39	2.65	2.73	2.56	2.94	3.10	3.08	3.18	3.00	2.89	2.87	2.71	2.95	2.888
42	2.85	2.81	2.74	2.99	2.93	3.07	2.93	2.84	2.98	2.83	2.63	2.75	2.862
45	2.88	2.74	2.78	3.01	3.04	3.17	3.05	3.10	3.01	3.07	2.72	2.88	2.954
48	2.78	2.86	2.93	3.14	3.17	3.53	3.00	3.18	3.13	3.06	2.81	3.19	3.065
51	2.73	2.70	2.99	3.00	3.15	3.24	3.01	3.01	3.03	3.11	2.92	2.86	2.979
54	2.85	2.81	3.06	3.11	3.37	3.36	3.16	3.16	3.18	2.98	2.94	3.02	3.083
57	3.13	2.94	3.11	3.09	3.30	3.46	3.19	3.20	3.14	3.19	2.92	3.25	3.160
60	2.96	3.09	3.04	3.19	3.34	3.37	3.20	3.15	3.22	2.99	2.93	2.93	3.117
63	3.01	3.94	3.31	3.25	3.40	3.35	3.21	3.17	3.19	3.32	3.04	3.25	3.203
66	2.95	2.99	3.22	3.11	3.50	3.35	3.25	3.30	3.14	3.09	3.26	3.02	3.180
69	3.08	2.78	3.22	3.30	3.53	3.39	3.17	3.28	3.19	3.04	3.19	3.33	3.208
72	3.20	3.00	3.49	3.33	3.49	3.25	3.37	3.20	3.27	3.35	3.30	3.33	3.298
75	2.99	3.25	3.33	3.43	3.40	3.30	3.32	3.42	3.15	3.22	3.19	2.94	3.245
78	3.03	3.23	3.39	3.16	3.64	3.43	3.29	3.37	3.35	3.18	3.26	3.12	3.287
81	3.23	3.33	3.35	3.78	3.60	3.52	3.44	3.32	3.20	3.09	3.31	3.17	3.362
84	3.23	3.37	3.28	3.51	3.52	3.41	3.36	3.44	3.46	3.15	3.31	3.55	3.382
87	3.21	3.43	3.74	3.55	3.57	3.39	3.33	3.39	3.35	3.15	3.33	3.24	3.390
90	3.18	3.43	3.58	3.63	3.55	3.51	3.38	3.57	3.14	3.19	3.63	3.40	3.432
93	3.04	3.54	3.42	3.53	3.55	3.50	3.30	3.50	3.36	3.26	3.32	3.24	3.380
96	3.18	3.29	3.85	3.59	3.57	3.51	3.50	3.54	3.38	3.46	3.51	3.46	3.487
99	3.28	3.48	3.26	3.60	3.67	3.35	3.31	3.36	3.43	3.57	3.29	3.58	3.432

TABLE 3

Showing the average characteristics of the air cells of eggs of different ages, from newly laid to 99 days old

AGE OF EGGS	AIR CELL INDEX	AIR CELL—EGG HEIGHT PERCENTAGE	AIR CELL—EGG DIAMETER PERCENTAGE
days			
Newly laid	0.108	2.78	33.84
3	0.144	4.54	43.43
6	0.163	5.93	49.69
9	0.176	7.10	54.61
12	0.194	8.42	58.15
15	0.207	9.32	60.46
18	0.216	10.31	62.76
21	0.219	10.57	64.39
24	0.237	11.72	67.33
27	0.243	12.65	68.83
30	0.254	13.33	70.73
33	0.262	13.80	71.00
36	0.273	14.51	73.51
39	0.277	15.13	74.49
42	0.273	15.32	74.86
45	0.278	15.81	76.10
48	0.272	17.45	79.10
51	0.291	16.63	77.60
54	0.307	18.35	80.12
57	0.322	19.60	81.58
60	0.313	18.83	81.16
63	0.322	19.90	82.89
66	0.322	19.82	83.02
69	0.336	20.96	83.63
72	0.332	21.48	85.93
75	0.339	21.26	84.34
78	0.341	21.94	85.21
81	0.355	23.44	87.52
84	0.363	24.00	89.18
87	0.372	23.63	88.39
90	0.360	24.10	89.35
93	0.361	23.81	89.31
96	0.395	25.67	91.23
99	0.370	25.01	90.14

TABLE 4

Showing the statistical treatment of the means of each of the different physical qualities of new-laid, 15-day-old, 30-day-old, 45-day-old and 60-to-90-day-old eggs

AGE OF EGGS	MEASUREMENT	HEIGHT OF THE AIR CELL	DIAMETER OF THE AIR CELL	AIR CELL HEIGHT-EGG HEIGHT PERCENTAGE	AIR CELL DIAMETER-EGG DIAMETER PERCENTAGE	AIR CELL INDEX
days		*cm.*	*cm.*			
New-laid	Mean	0.142 ± 0.002	1.314 ± 0.002	2.780 ± 0.042	33.840 ± 0.119	0.108 ± 0.018
	Coefficient of variability	0.770 ± 0.106	0.762 ± 0.105	7.610 ± 1.048	1.723 ± 0.237	8.273 ± 1.139
15	Mean	0.483 ± 0.066	2.337 ± 0.034	9.520 ± 0.291	60.460 ± 0.826	0.207 ± 0.045
	Coefficient of variability	16.867 ± 2.393	7.274 ± 1.002	15.365 ± 2.116	6.725 ± 0.926	10.724 ± 1.477
30	Mean	0.688 ± 0.018	2.709 ± 0.034	13.530 ± 0.440	70.730 ± 0.997	0.254 ± 0.043
	Coefficient of variability	13.023 ± 1.793	6.238 ± 0.859	16.212 ± 2.232	6.909 ± 0.951	8.386 ± 1.155
45	Mean	0.820 ± 0.18	2.954 ± 0.029	15.810 ± 0.373	76.100 ± 0.810	0.278 ± 0.038
	Coefficient of variability	11.330 ± 1.560	4.841 ± 0.667	11.613 ± 1.599	5.247 ± 0.722	7.014 ± 0.966
60	Mean	0.976 ± 0.023	3.117 ± 0.023	18.830 ± 0.478	81.160 ± 0.617	0.313 ± 0.047
	Coefficient of variability	11.568 ± 1.593	3.245 ± 0.031	12.496 ± 1.721	3.743 ± 0.515	7.300 ± 1.005
75	Mean	1.101 ± 0.030	4.684 ± 0.645	21.260 ± 0.535	84.340 ± 0.630	0.339 ± 0.065
	Coefficient of variability	13.860 ± 1.908	4.653 ± 0.641	12.366 ± 1.703	3.676 ± 0.506	9.469 ± 1.304
90	Mean	1.237 ± 0.030	3.432 ± 0.035	24.100 ± 0.687	89.350 ± 0.554	0.360 ± 0.060
	Coefficient of variability	11.930 ± 1.643	4.982 ± 0.686	13 983 ± 1.925	3.049 ± 0.420	8.167 ± 1.125

ABSTRACT[1]

Effect of fertilizers on the growth and development of Chinese dwarf banana (Musa cavendishii Lambert).—NICANOR C. MANIPULA. *(Thesis presented for graduation, 1934, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 497; Experiment Station contribution No. 1122.)* The objects of the experiment were: (*a*) To study the effect of certain fertilizers on the growth and development of Chinese dwarf banana; (*b*) to find the influence of fertilizers on the catalase activity of the banana leaves.

A total of 144 "sword leaf" type suckers were used for planting; 96 of these were planted in earthen pots of the same size, and 48 were planted in plots in the orchard. The experiment was carried out in 3 sets in both pot and plot cultures. Each set comprised 16 plants; these were given treatments of various fertilizer combinations. The combinations contained 25 per cent of each of nitrogen, phosphoric acid and potash. The fertilizers were applied singly or in combinations to each plant in each set, except the control which did not receive any fertilizer. The fertilizers were applied in shallow trenches made around the base of the plants. These trenches were all the same distance from the plants.

The following combinations of fertilizers were applied. The first quantity is nitrogen, the second, phosphoric acid, the third, potash. (For example plot 1, 100 grams nitrogen –0 gram phosphoric acid –0 gram potash).

Plot (1) 100-0-0; plot (2) 75-25-0; plot (3) 75-0-25; plot (4) 50-50-0; plot (5) 50-25-25; plot (6) 50-0-50; plot (7) 25-75-0; plot (8) 25-50-25; plot (9) 25-25-50; plot (10) 25-0-75; plot (11) 0-100-0; plot (12) 0-75-25; plot (13) 0-50-50; plot (14) 0-25-75; plot (15) 0-0-100; and plot (16) control, no treatment.

The criteria for growth of plants were: green weight, height of plants, diameter of trunk, weight of roots and corms, number of leaves, number of suckers and number of roots.

In determining the catalase activity, Heinicke's method was followed. Samples of leaves were gathered with a cork borer, 5 mm. in diameter. About 100 to 150 discs were taken from each leaf. The leaves were all in about the same condition. The samples for the sixteen treatments were taken from three hills of field plants and from three potted plants. Duplicate determinations from each sample were made.

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[1] Abstract prepared as part of theme work required in English 3a, College of Agriculture.

Some of the results obtained were:

1. The pot culture No. 5 treated with 50 per cent N (50.9 grams), 25 per cent P_2O_5 (20.1 grams) and 25 per cent K_2O (6.2 grams) gave the best results for green weight, diameter of trunk, weight of roots and corm and number of roots. The results were all significant.

2. The plot culture No. 6 which received 50 per cent N (407.5 grams) and 50 per cent K_2O (98.6 grams) gave the best results in diameter of trunk, height of plants, number of suckers, early bearing and weight of bunches. Increase in height and weight of bunches were both significant; but increase in diameter of trunk and number of suckers were both insignificant.

3. Catalase activity in mature leaves of the banana was more active than in the young leaves. This was found to be true in both the plot and the pot cultures.

4. No relationship was found between catalase activity and the green weight of plants.

—Abstract by Segundino O. Barraquero

COLLEGE AND ALUMNI NOTES

According to the figures furnished by the office of the secretary of this College, 192 regular students were registered during the summer, 1936, and 471 at the opening of the first semester, in June. Of the first-semester registrants, 136 were new.

The College of Agriculture held its fifth Rural Life Institute from May 18 to 23, with an attendance of 20.

The 1936 summer extension classes of the College held their commencement exercises at the auditorium on May 23, in which 52 students received their certificates, 4 in industrial utilization of farm products, 21 in plant propagation, and 27 in poultry raising.

The graduation of the following students with the degree of B. S. Agr. was approved on June 3: Antonio C. Alberto, Leona Atienza-Dacanay, Crispin K. Dacanay, and Onofre F. Martin.

Summer trips were made by faculty members as follows:

Dr. F. O. Santos, during the first week of April, to Camarines Sur, to study the food of laboring families in that locality.

Dr. Pablo N. Mabbun, during April, to the province of Cagayan, in order to survey farm-credit conditions.

Dr. Valeriano C. Calma, in April, to Iloilo, Negros and Cebu, for a survey of the sugar districts.

Dr. L. B. Uichanco, in April and May, to Mindanao, to study the locust situation. He was accompanied by Dr. Gonzalo Merino, of the Bureau of Plant Industry, during a part of the trip.

A testimonial dinner was tendered the Reverend and Mrs. Hugh Bousman on May 26 by members of the faculty of the College of Agriculture and the School of Forestry on May 26, on the occasion of their departure for their new pastorate in Dumaguete. The Bousmans have been conspicuously active in social work among the students in our College community, where Mr. Bousman was for several years pastor of the United Evangelical Church.

The greater part of the participation at the University of the Philippines' faculty conference in Baguio on May 11 to 16 was composed of delegates from the College of Agriculture. Fifteen members joined, representing all the departments. These were: Dean B. M. Gonzalez, Dr. D. I. Aquino, Prof. Vicente Aragon, Dr. Silverio M. Cendaña, Dr. Pedro A. David, Dr. Antonio I. de Leon, Prof. Josefa D. Diaz, Dr. R. B. Espino, Dr. G. Guanzon, Dr. N. B. Mendiola, Mr. E. F. Roldan, Dr. F. M. Sacay, Dr. F. O. Santos, Dr. A. L. Teodoro, and Dr. Valente Villegas. Dean Gonzalez was chairman of a section of the conference.

His Excellency, the President of the Philippine Commonwealth appointed a committee to investigate the various government agricultural experiment stations. The alumni of this College, who constitute all but one of the membership, are: Dr. M. L. Roxas, '11, chairman, Dr. N. B. Mendiola, '14, Dr. Vicente C. Aldaba, '15, and Mr. Hilarion S. Silayan, '17.

Mr. Jose S. Camus, '14, until lately director of plant industry, was appointed undersecretary of the Department of Agriculture and Commerce. Mr. Hilarion S. Silayan, '17, became Mr. Camus' successor as director of plant industry.

Two new appointments to the College faculty include Mrs. Josefa Desiderio-Diaz, A.B., M.A., University of the Philippines, assistant professor of agricultural education, and Mrs. Ruth McCullough-Mack, a graduate of De Pauw University and M. A., Radcliffe, assistant professor of English. Both have had a number of years' experience in teaching, Mrs. Diaz in a Philippine private academy, and Mrs. Mack in Lingnan University, Canton, China.

CULTURE AND AGRICULTURE[1]

One of the problems connected with technical education in agriculture is the somewhat crowded curriculum called for by the exigencies of the complex subject-matter. There is left but little room for inclusion of such courses as the humanities and allied disciplines that go to make for a broader culture. The result is that, not only as students, but also as graduates, those who embrace this profession are often destined to go through life deeply intrenched in their own narrow channel of specialization, with their sense of perception and appreciation more or less dulled to other things. Perhaps human society has become so highly organized that it has come to demand this caste-like limitation. It is a well-known biological truth, however, that overspecialization in an organism is attained at the expense of certain fundamentally important structure or function, whereby the individual becomes a misfit in nearly all other phases of the social pattern.

In the exercise of the rational faculties, the old epigram about the ideal educated man, as one "who knows a little of everything and everything of something," has a great deal to commend it. Incursion into other realms of knowledge, instead of entailing a wasteful dissipation of effort, engenders that breadth of viewpoint that is necessary for a balanced judgment. A part of the leisure hours devoted regularly each day to general reading, for instance, will supply our students in agriculture some of the cultural seasoning that is denied them in their regular college course. A great deal of mental stimulus may, likewise, be derived from attempts at a more thorough understanding of the world about us. The places in and around the College campus itself are full of historical, scientific, and general cultural interest. Our modern automobile driveways, for one, follow the course of the old Spanish roads over which in an earlier century the *carruajes, quiles,* or palanquin often brought the *capitan general* and his gay official parties for a day of rest in the baths operated by the Franciscan mission. The Great Ice Age, when fearful volcanic activities pervaded this part of Luzon Island, has left its footprints behind in the new extinct Mt. Maquiling, Laguna de

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[1] General contribution No. 528. Modified from an address of the writer at the opening exercises of the College of Agriculture on June 8, 1936.

Bay, the white-clay deposits and the beautiful crater lakes of Natugnos and Tadlak. Time was when these places were peopled by gods and demons and giants and fairies, stories about whom trickle down to this day in the delightful legend of Maria Maquiling. And what fanciful traditions, now lost in antiquity, must have been attached to the meter-wide open flower of *Rafflesia*, one of the largest flowers in the world, which one can sometimes find in our middle-altitude forests on Maquiling, or to the tiny *dulong*, a gobiid of Laguna de Bay, one of the smallest vertebrates in the world! The very collection of economic plants on the College campus each whispers its intriguing tale; the rice, of the wanderings of our Malayan ancestors who began to find their way across the seas into the Philippines a couple of millenia before Christ; the common guava, chico, guayabano, tomato, and many other trees, shrubs, and herbs, of the tedious voyages of the galleon to Acapulco, of daring buccaneers, of cathedral bells and *Te Deums*, of fortunes made and lost from the distribution of the *boletas;* the marang, of the brave and proud race of Joloanos, who never submitted to the Spanish yoke and whose written history antedates ours by about five centuries. In a place like the College of Agriculture, where we draw our student population from all over the Islands and from neighboring countries, especially Siam and China, one gets in contact with a Pampango, who calls his rice *nasi*, just as the Soendanese of Java call theirs, or listens to an Ilocano *kundimon* in that same falsetto key that one often hears among the red-sashed natives of Singapore. The sympathetic listener recalls in such experiences the essential unity of the Malay peoples as he lives over again the glamorous days of the great Malay empires, the Shri-Vishaya and its successor, the Madjapahit, from the ninth century of the Christian Era to the fourteenth.

Perhaps in a materialistic world, such a feature of education may seem archaic; but certainly a person could live a fuller life whose cultural training enables him to pause once in a while from his arduous professional duties and find relaxation in capturing the subtle poise of the well-bred from classical literature, in composing a musical piece or a poem, in tracing a country's geology in fault blocks, anticlinoria, Pliocene limestones and laterites, in learning some great biological truth from a bee entering a flower or a weaver building its nest, in reading and interpreting the messages of the clouds, the wind and the stars, or in penetrating the labyrinthine history of an ethnic group among whom he may live with the aid of its language, customs, prejudices, superstitions and forgotten fragments of porcelain preserved in ancient tombs.

Moments of solitude, with relative freedom from disturbance, are admittedly essential for reflection in a creative mind. The retreat he finds, possibly among some mossy old stone walls, smelly shops, a quiet church corner, or an insect-infested forest, all that would otherwise be a confused medley of stark realism, becomes to him an outer sphere of such rare charm that only the following sublime lines from Wordsworth could do it justice:

> Earth has not anything to show more fair:
> Dull would he be of soul who could pass by
> A sight so touching in its majesty:
> This City now doth like a garment wear
> The beauty of the morning: silent, bare,
> Ships, towers, domes, theatres and temples lie
> Open to the fields, and to the sky;
> All bright and glittering in the smokeless air.
> Never did sun more beautifully steep
> In his first splendour valley, rock or hill;
> Ne'er saw I, never felt, a calm so deep!
> The river glideth at its own sweet will:
> Dear God! the very houses seem asleep
> And all that mighty heart is lying still!

His bearings adequately established in their proper cultural setting, one could then begin to overcome boredom from the dull monotony of routine and experience a real thrill of adventure in his chosen line of work. He will then realize that great exploits do not consist solely in adding to the world a new continent. There are equally as dramatic angles in creating a new sugar cane according to specifications in a comparatively short time, in rescuing the common alcohol from the dingy drugstore lamp and forcing it by engineering skill through the carburetor of internal-combustion engines in order to turn the country's wheels of commerce, in seeing Canton, China, re-import as improved stock the Los Baños Cantonese chicken, the ancestors of which had originally come from the same breed that has been raised in that Chinese city for a long time, in producing that custom-built, streamlined tropical Berkjala, which is fully the peer of most temperate-country standard breeds of pigs, or in disentangling vexing problems of human, plant, or animal diseases through patient research. The laboratories and fields of exploration, to be sure, become a veritable treasure house that guards in hidden recesses some romantic secret.

LEOPOLDO B. UICHANCO
Managing Editor

RESISTANCE OF THE BERKJALA BREED OF SWINE TO HOG CHOLERA[1]

MIGUEL MANRESA AND M. MONDOÑEDO
Of the Department of Animal Husbandry

WITH TWO TEXT FIGURES

Of the thousands of people who have seen the Berkjala pigs in the College of Agriculture, in livestock expositions held in connection with the Manila Carnival, in the penal colonies or farms under the Bureau of Prisons, in agricultural schools in various places in the Philippines, and on many private farms a query as to the origin of this breed must have come to the minds of many. This paper is an answer to this query.

It was some twenty odd years ago that the first crosses involving the purebred Berkshire and the Native pigs from Jalajala were made in the College of Agriculture with a definite object. This object was to incorporate into one breed such characteristics as would enable the animal to thrive under Philippine conditions and possess the qualities of early maturity and the desirable conformation of the imported Berkshire. To give due credit to the original stock used in the cross these pigs were named Berkjala.

The early part of this work was described by Gonzalez[2] in 1932. It is a story of hopes and disillusions. But to a stockman interested in improving his stock by breeding, the story is not a dull one and, like all good stories, it ends well. For we now have in the Berkjala a breed that is undergoing constant purification and improvement. It is already better than the Berkshire or any other Occidental breed for the Philippines in ability to live, grow and propagate under our conditions, and is better than the Native in the rate of growth, size and response to domestication and rational methods of feeding.

As an example of the ability of the Berkjala breed to propagate and multiply, the successful venture of our Bureau of Prisons in swine raising may be cited. The raising of farm animals acquired some prominence among the projects of that bureau soon after Colonel Paulino Santos had been appointed Director. Among the several

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[1] Experiment Station contribution No. 1125. Received for publication December 23, 1935.

[2] GONZALEZ, B. M. 1932. Animal improvement program of the College of Agriculture. The Philippine Agriculturist 21: 1–8. *Fig. 1–6*.

breeds of pigs given a trial, the Berkjala pigs were included. In 1931 the bureau acquired its first stock of Berkjala pigs from the College of Agriculture; this stock consisted of two males and six females. In 1932 two males and 21 females were purchased. That the propagation of these animals is rapid has been demonstrated by the Bureau of Prisons, for Berkjala pigs may now be found in all the Penal Colonies of that Bureau, including the one started in 1933 in Davao, Mindanao. In the Iwahig Penal Colony alone, in Palawan, there were over four hundred of these pigs in April, 1935. The writers do not know of a better demonstration of using with success a breed of livestock formed locally under scientific methods for a herd to be used on a farm for profit, giving proper care, feeding and management.

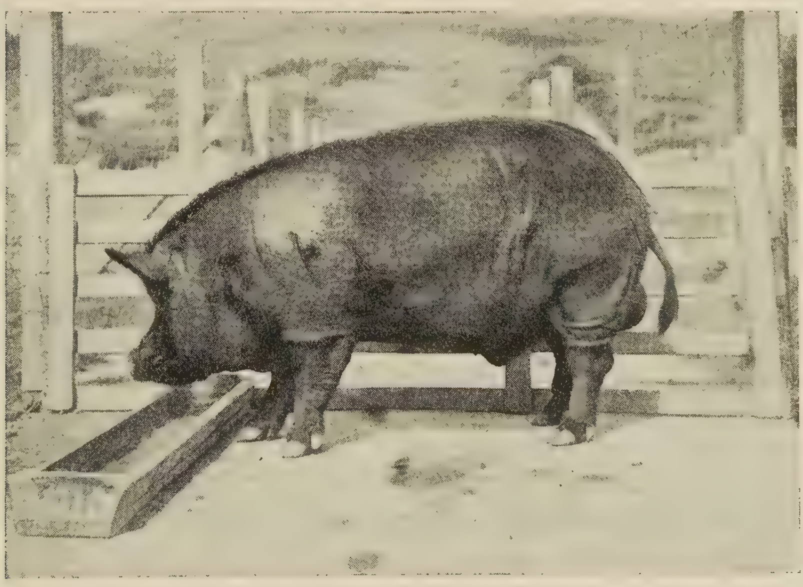

Fig. 1.—A Berkjala boar, weighing 158 kilograms at age of three years.

In all undertakings it is necessary to take stock of one's work periodically for the purpose of finding out where one stands. This inventory has been done in connection with our work on the Berkjala pigs. In 1931 a critical study was made of the records of some 1,693 pigs produced in the College of Agriculture from 1916 to 1931. (Banaag, 1931).[3] For purposes of comparison the time from 1916 to 1931 was divided into three periods of five years each. The study showed that the duration of serviceable life of the sows that were retained in the herds for breeding purposes had increased steadily. The size of litters had decreased in the second period but had overcome this decrease and more so in the third period. The number of pigs weaned from each litter was raised gradually so that by the end of the third period more pigs to the litter were weaned than in the first. Towards the end of the third period there was greater uniformity in size, color, and conformation, and the weights at given ages were greater than in the two previous periods. Taking the records of the whole population of pigs during the third period, it was found that the average weight of the pigs at birth was 0.96 kilograms. At weaning time, eight weeks after birth, it was 4.65 kilograms. At six months of age the pigs averaged 15.71 kilograms; at one year, 53.34 kilograms; and at two years, 100 kilograms.

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[3] BANAAG, LEONARDO. Studies on the Berkjala breed of pigs with special reference to the weight, and adaptability to local conditions. (Thesis presented for graduation with the degree of Bachelor of Agriculture, 1931. Unpublished.)

In the early years of the work, some of the important points aimed at in establishing this breed were: (1) ability of the sows to produce two litters of pigs in one year with at least eight pigs to the litter and ability to raise 80 per cent of the young; (2) the attainment of a live weight of 80 kilograms at the end of one year; and (3) the production of a ham-bacon type of hog that will breed true to type. By using indices for selection based on certain standards of requirement, it has been possible to shift gradually the direction of the work towards these objectives. (Manresa, 1934) [4]

The standards for the present are: *litter size,* a minimum of six pigs to the litter at first farrowing, seven in the second farrowing, and eight in the third and subsequent farrowings; *motherly characteristics,* being able to raise not less than 75 per cent of the young; and *milking quality,* a minimum total weight of litter at weaning of 50 kilograms for the first litter, 60 kilograms for the second and 80 kilograms for the third and subsequent litters. It is obvious that if progress is to be maintained, these limits will have to be raised as soon as the majority of the animals in the herd are able to satisfy the standard requirements. In culling, the animals rating low judged on the basis of the indices are, of course, discarded. Returns from the sale of the discarded animals furnish the necessary means for the successful continuation of the work.

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[4] MANRESA, M. 1934. A quarter century of work on animal improvement. The Philippine Agriculturist **23**: 433–443. *Fig. 1–2.*

Selection for vigor and resistance against disease has not been overlooked. An outbreak of hog cholera reported in 1922[5] in the swine herds of the Department caused a rather high rate of mortality. Gonzalez states that the pigs left after the outbreak could be counted on the fingers of one hand. But the few pigs surviving were vigorous and reproduced rapidly. No infectious disease broke out in our herds again until the latter part of 1935, and we have reason to believe that some progress has been made along the line of selection for resistance against disease. Evidence of this is the relatively low percentage of mortality of pigs during the 1935 infection. But we have not had an opportunity to compare the Berkjala pigs with other breeds of pigs as to resistance against hog cholera. Coronel[6] reported an outbreak of swine disease in the Correctional Institution Hog Farm of the Bureau of Prisons at Mandaluyon, Rizal. Poland China pigs, Berkjalas and Duroc Jerseys were raised side by side on this farm. In June, 1934, when the mortality among the pigs on the farm had become alarming, there were in the farm herd 120 Poland China, 100 Berkjala and 55 Duroc Jersey pigs.

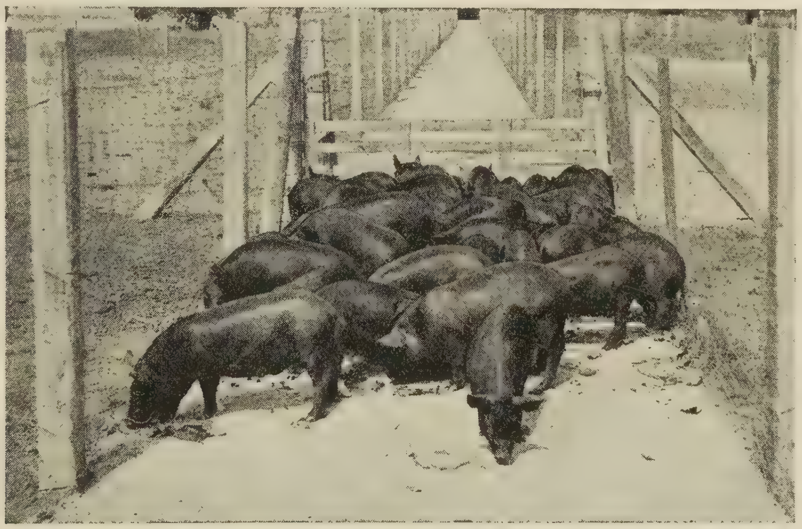

Fig. 2.—Weanling pigs descended from a hog-cholera resistant stock.

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[5] GONZALEZ, B. M. 1922. Hog cholera at the College of Agriculture. The Philippine Agriculturist 10: 347–348.

[6] CORONEL, ANACLETO B. 1935. A résumé of the outbreak of swine diseases in the Bureau of Prisons' Hog Farm in 1933–1934. The Philippine Journal of Animal Industry 2 (5): 327–332.

The disease was first observed in the pen where newly weaned pigs of the three breeds were mixed, a procedure that is still being followed on account of the limited size of the farm. Information from the authorities of the institution states that the disease spread rapidly in a short time and that deaths were observed in all of the three breeds. The Bureau of Animal Industry undertook the task of determining the cause of the infection and having diagnosed the existence of hog cholera, according to Coronel, some 116 pigs were "immunized" (inoculated) with anti-hog cholera serum on August 5, 1934. More inoculations were made after that date.

Through the courtesy of the Director of the Bureau of Prisons it has been possible for us to compute the percentages of mortality in the different breeds of pigs on this Hog Farm before the outbreak of the epizootic, during the outbreak of the disease and after the epizootic had been controlled.[7]

TABLE 1

Percentages of mortality before the epizootic from January 1 to May 31, 1934

Breeds	Maximum number of pigs during the period	Number of pigs which died during the period	Rate per cent of mortality	
			In 5 months	Av. per month
Duroc Jersey	55	13	23.63	4.73
Poland China	114	20	17.54	3.51
Berkjala	74	6	8.11	1.62

TABLE 2

Percentages of mortality during the epizootic from June 1 to October 31, 1934

Breeds	Maximum number of pigs during the period	Number of pigs which died during the period	Rate per cent of mortality	
			In 5 months	Av. per month
Duroc Jersey	55	44	80.00	18.00
Poland China	120	71	59.18	11.83
Berkjala	100	48	48.00	9.60

These two tables show that the mortality rate among the Berkjala pigs remained low both before and during the epizootic. The production during a period of five months, from June to October, was 80 for the Berkjala, 4 for the Poland China, and none for the Duroc Jersey. Except in the case of the Duroc Jersey pigs, there was a progressive decrease in the percentages of mortality after August 5, 1934, and although the mortality from all causes in September, October, November and December, 1934, was higher than in the five months previous to the outbreak of the swine diseases, it may be said that the infection was practically under control by the end of October, 1934 (Coronel, 1935).

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[7] These data were obtained from the records on the Hog Farm through the courtesy of Director Paulino Santos. Acknowledgment of our indebtedness is here made and appreciation expressed. M. M.

As inoculations with anti-hog cholera serum were made begining August 5, 1934, the period during the epizootic may be divided into two periods: (1) period before the inoculations from June 1 to August 5, and (2) the period after inoculation from August 6 to October 31, 1934. The percentages of mortality in each of these periods are given in tables 3 and 4.

TABLE 3

Percentages of mortality before "immunization" (inoculation)

Breeds	Maximum number of pigs during period from June 1 to Aug. 5, 1934	Number of pigs which died from June 1 to Aug. 5, 1934	Rate per cent of mortality	
			In 2.16 months	Av. per month
Duroc Jersey	55	14	25.45	11.78
Poland China	120	48	40.00	18.52
Berkjala	100	18	18.00	8.33

TABLE 4

Percentages of mortality after "immunization" (inoculation)

Breeds	Maximum number of pigs during period from Aug. 6 to Oct. 31, 1934	Number of pigs which died from Aug. 6 to Oct. 31, 1934	Rate per cent of mortality	
			In 2.83 months	Av. per month
Duroc Jersey	44	30	68.18	24.18
Poland China	68	23	33.82	11.95
Berkjala	88	30	34.09	12.04

The data in these two tables show that, with the possible exception of the Poland China, in which the percentage of mortality was reduced by 6.57 per cent after "immunization" (inoculation), all the breeds showed increased mortality after inoculation, presumably with anti-hog cholera serum, than before inoculation. The increase was 3.71 per cent in the case of the Berkjala, and 12.40 per cent in case of the Duroc Jersey. From these results it does not seem that the effects of inoculations were manifested shortly after administration.

Since from a practical standpoint the success of any breed of hogs must be judged on the ability of the animals to multiply and propagate under various conditions, it was deemed important to follow up and note the performance of the animals in these respects after the epizootic had been controlled.

TABLE 5

The rate of reproduction after the epizootic during a period of thirteen months from November 1, 1934 to December 1, 1935

Breeds	Number of pigs on Nov. 1, 1934, that is, after the epizootic	Number of pigs on Dec. 1, 1935, that is, 13 months without infection	Increase or decrease
			per cent
Duroc Jersey	30	18	— 40.00 (decrease)
Poland China	45	70	+ 55.55 (increase)
Berkjala	62	114	+ 83.87 (increase)

It was found, as may be seen in table 5, that during a period of thirteen months after the epizootic, that is, from November 1, 1934 to December 1, 1935, the Duroc Jerseys decreased in number by 40.00 per cent, the Poland Chinas increased 55.44 per cent, but the Berkjala increased 83.87 per cent. If the number of each kind or breed of pigs present on the farm on December 1, 1935 is compared with the maximum number in each breed present during the period from January 1, 1934 to May 31, 1934 (see table 1), there would appear to be a decrease of 67.27 per cent in the case of the Duroc Jersey, and also a decrease of 38.59 per cent in the case of the Poland China, but an increase of 54.05 per cent in the case of the Berkjala. If the purpose of raising pigs is to make money, the data given above for the Correctional Institution of the Bureau of Prisons at Mandaluyon, Rizal, certainly fail to show the advantage of Duroc Jerseys or Poland Chinas over the Berkjala pigs.

The superiority of the Berkjala pigs in point of vigor, fertility, ability to live and propagate under local conditions, as well as in response to domestication and rational methods of feeding, have been repeatedly demonstrated in carefully controlled experiments. In the building up of this breed of pigs selection for resistance against disease has not been overlooked. We have reasons to believe that much progress has been made in developing a strain of pigs with high resistance against hog cholera. The present data leave no doubt on this point.

PLANT-FOOD RESERVE IN LOWLAND AND UPLAND SOILS [1]

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It is a well known fact that the differences in the chemical composition of soils have a marked influence upon their fertility. The chemical analysis of soils gives an insight as to the amount of the plant foods held in reserve in the soils and interests vitally permanent settlers. Because the water-soluble plant foods in the soils rarely suffice for the food requirements of a crop during the whole growing season, the plant food reserves in the soils, supplement, so far as possible the shortage to the plants either by weathering or by the direct action of the acids secreted by the roots of the plants. As to whether lowland soils are more intensively weathered than upland soils is not known.

The main object of the present work was to determine the plant foods of lowland and upland soils held in reserve and to find out which of the two soil classes is more intensively weathered.

REVIEW OF LITERATURE

Early studies on Philippine soils by Dorsey (1903), Cox (1911), Cox and Arguelles (1914), and others were exhaustively reviewed by Pendleton (1935). Not only have the soil surveys and studies on the chemical, mechanical, physical, and microbiological aspects of soils been compiled but also related studies made on Philippine soils. For this reason, the present paper considers only foreign studies directly connected with the subject.

Liebig, cited by Blanck and Haselholff (1927), established the so-called "mineral theory". It emphasized the importance of the inorganic constituents of soils in the nutrition of plants. Thoms, according to Koenig (1906), claimed that the fertility of soils is not only dependent on the amount of water soluble plant nutrients in the soils but also on the essential plant foods held in reserve: namely, nitrogen, phosphorus, calcium, potassium and magnesium. Opitz,

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[1] Experiment Station contribution No. 1126. Received for publication April 13, 1936. The greater part of the experiment was performed by the writer in the laboratory of the Department of Agricultural Chemistry.

cited by Ramann (1911), found that Silesian soils containing 0.10 per cent P_2O_5 soluble in hydrochloric acid do not need phosphatic fertilizer. Weibul, according to the same authority, found that light soils containing 0.15 per cent K_2O may not respond to the application of potassic fertilizers. Bieler, cited by Ramann (1911), reported that soils containing 0.10 to 0.15 per cent N_2 and 0.50 to 1.00 per cent lime may be considered as good soils. Liebscher, according to Blanck (1928), claimed that the solubility of P_2O_5 is greatly influenced by the amount of iron and aluminum oxides in the soils.

MATERIALS AND METHODS

The soil samples used in this study were obtained from some of the lowland and upland farms[2] in the town of Bay and in the College of Agriculture, Laguna Province. Lowland farms are generally found in countries growing rice (*Oryza sativa* L.) and zacate (*Leersia hexandra* Swartz) and are tilled when submerged in water. Unlike lowland farms, upland farms are found in all parts of the earth; they are tilled when the moisture content of the soils is about 18 to 30 per cent. Upland farms may be planted to various kinds of crops.

In taking soil samples, accumulation of organic matter on the surface was first removed. The subsoils and the surface soils were separately sampled and chemically analyzed. These samples were all clay-loam soils.

Before subjecting the soils to chemical analysis, they were dried in the air, pulverized, sieved through 2-mm sieve and put in well-stoppered bottles. As the soil constituents which may be dissolved only by fusing with alkali carbonates or by evaporating with hydrofluoric acid have almost no value as plant foods; only soil constituents which are dissolved by hydrochloric acid are considered in the present study. Hilgard (1911) assumed that prolonged action of the roots and soil solvent would, in the course of time, act similarly to hydrochloric acid. The extraction of the soil constituents by 10 per cent HCl was carried out according to the method recommended by the second commission of the International Society of Soil

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[1] Bay soils were obtained in the barrio of Puypoy, along the road leading to Masaya, a barrio of Bay. The samples are here numbered 5, 6, 9, 10, 11, and 12. The College Farm soils, numbered 1, 2, 3, were obtained from Agronomy 13 plots; 4 in the Experiment station farms along the provincial road between Bay and Los Baños; and 7 and 8 from Doctor Baltazar's and Doctor Calma's field experiments.

Science, as modified by Blanck and Rieser (1928). Total nitrogen and loss on ignition contents were determined in accordance with the method of the Association of Agricultural Chemists (1930), and the organic matter content, according to the technique of Rieser (1931).

RESULTS AND DISCUSSION

The results of the chemical analysis, of lowland and upland soils are given in tables 1 and 2.

It may be seen in table 1 that the dissolved soil constituents in 10 per cent HCl extracts of the lowland soils do not have uniform concentration. The silica dissolved by the acid treatment varies from 0.35 to 0.56 per cent and the amorphous silicic acid soluble in 5 per cent sodium carbonate from 3.15 to 4.30 per cent. This non-uniformity is observed not only on silica but also on the concentration of the other soil constituents; namely, Al_2O_3, Fe_2O_3, CaO, MgO, K_2O, Na_2O, P_2O_5, SO_3 and insoluble residue. The amounts of loss on ignition convey the same conclusion. It is interesting to note that the amounts of Al_2O_3 and Fe_2O_3 dissolved by 10 per cent HCl are much higher than those of the other oxides and that amount of Al_2O_3 is in all cases much higher than the corresponding amount of Fe_2O_3.

Further examination of the table reveals that the amounts of the insoluble residue vary from 59.84 to 64.24 per cent, which shows that the greater portion of lowland soils is still present in its mineral forms. It may also be seen that the amounts of loss on ignition in all the samples studied are much higher than the corresponding amounts of organic matter. This is because on igniting the soils not only organic matter and chemically combined water are evolved but also carbon dioxide, alkali chlorides and sulfur trioxides from iron sulfate. Rieser (1931) maintains the same conclusion. Warington (1900) likewise brings out the same facts. Loss on ignition is thus no measure of the amount of organic matter present in the soils.

As the figures stand in table 2, the non-uniformity of the concentration of the soil constituents in table 1 is here also observed. It may be noted in table 2 that the amounts of Al_2O_3 show the tendency to be lower than the corresponding amounts of Fe_2O_3, which is, however, not true in the number 11 soil sample. Unlike that of the lowland soils, the percentages of CaO are not always higher than the corresponding percentages of MgO. Soils numbers 7 and 8 contain only 0.80 per cent 0.75 per cent CaO, respectively, while the corresponding amounts of MgO are relatively higher, being 1.11 per cent and 0.99 per cent.

Since subsoils may serve also as a good source of plant nutrients, its plant food held in reserve need, therefore to be considered. On rainy days, the soil solution of the surface soils penetrates into the subsoils, while on sunny days, the upward movement of the soil solution, caused by surface evaporation, takes place, thus increasing the plant foods in the surface soils.

The results of the various determinations made on the subsoils of the analyzed surface soils noted above are given in tables 3 and 4. It is apparent from the results in table 3 that the different soil constituents of the subsoils, like that of the surface soils, do not have uniform concentration. The conclusions recorded in table 1 are corroborated by the data in table 3.

It may be seen in table 4, that the concentrations of Al_2O_3 in the 10 per cent HCl extracts are in all cases lower than the corresponding amounts of F_2O_3. Also the amount of CaO dissolved by the acid in sample 7 is relatively lower than the amount of MgO.

To have an idea of the relative amounts of the plant foods held in reserve in lowland and upland soils as well as those in subsoils, the sum of the acid-soluble constituents, the acid-insoluble residue and the amount of loss on ignition of table 5 are treated statistically. The results of the calculation are given in table 6.

It may be noted in table 5 that the lowland surface soils contain more acid-soluble constituents than the upland surface soils, the difference in average as given in table 6 is significant, in favor of lowland soils. The average amount of insoluble residue of lowland soils is only 61.09 ± 0.15 per cent, while that of the upland soils is 71.06 ± 0.13 per cent, giving a difference of 9.97 ± 0.20 per cent. This difference, as indicated in table 6, is significantly higher in the upland surface soils. This may be due to the chemical action of the soil solution. Everything being equal, the more frequently a solution comes in contact with soil particles, the more intense its chemical decomposition. Hilgard (1911) stated that water is a potent factor in the chemical processes which cause the decomposition of soil-forming minerals. Vageler (1933) claimed that the moisture and temperature conditions within the soils influence soil processes and formation to a much greater extent than the corresponding conditions outside the soils. Unlike the inorganic soil constituents, the difference in average of the amount of loss on ignition is insignificant.

Comparing surface soils with subsoils, it may be seen in table 6 that the differences in the sum of the acid-soluble constituents, acid-insoluble residue and loss on ignition are all insignificant. These insignificant differences may be due to the upward movement of the soil solution. Warington (1900) stated that in dry weather the soil solution is brought to the surface of the soils by capillary action with the consequent accumulation of the different ions on the surface. King, cited by Bear (1929), expressed the same ideas. As shown by the figures, both lowland surface and subsoils are weathered to the same extent and the concentration of the acid-soluble constituents of soils, if they have been leached out on the surface, was equalized by the capillary movement of soil solution.

A further examination of table 5 shows that the data of the upland surface and subsoils do not agree with the data of lowland soils in showing the degree of weathering between the surface and the subsoil. The difference in average of the acid-soluble constituents, as shown in table 6, is significant, in favor of the upland subsoil, while that of the acid-insoluble residue is significantly higher in the surface soils. These findings would seem to indicate leaching on the surface soils. It is also obvious (table 5) that the amount of loss on ignition of the surface is relatively higher, as given in table 6, than that of the subsoils.

Considering lowland and upland subsoils, the preponderant effect of water on the chemical decomposition of the soil-forming minerals is again to be observed. These data corroborate the conclusion drawn in the comparison between lowland and upland surface soils.

With respect to the relative amounts of the principal plant foods; namely, nitrogen, phosphoric acid and potash in the soil studied, it is seen in table 6 that the difference in the average amount of nitrogen in lowland and upland surface soils is significant in favor of lowland surface soils. It is possibly due to a relatively excessive aëration and heating of upland soils, which does not occur in lowland soils. Blanck (1928) stated that the application of an equal amount of heat to an equal amount of water and dry soils raises the temperature of the dry soils much higher than that of the water. Unlike nitrogen the differences in averages of P_2O_5 and K_2O are both insignificant.

As the figures stand, the amount of nitrogen in the lowland surface and subsoils show significant difference, which is not true in the case of P_2O_5 and K_2O. This may be attributed to the continuous accumulation of organic matter on the surface. Insignificant difference of the amounts of phosphoric acid and potash in lowland surface and subsoils may be explained, as a result of the capillary movement of the soil solution.

The data for the principal plant foods held in reserve in upland surface and in subsoil confirm, as indicated in table 6, the conclusion drawn in the comparison of lowland surface and subsoils.

It is also to be seen in table 6 that the nitrogen and phosphoric acid held in lowland and upland subsoils are the same, while that of potash is significantly higher in upland subsoils.

To get an idea of the nature of the reserve plant foods of the Maquiling area soils, the average data found for the surface soils were compared with those of the Hawaiian soils. The results are given in tables 7 and 8.

Comparing the figures in table 7, it may be noted that the lowland soils, of the Maquiling area, are less intensively weathered than either the arid or humid soils of Hawaii. This fact is revealed by the significant difference, as given in table 8, of the sum of the acid soluble constituents. The differences in averages are 4.27 ± 0 74 per cent and 11.37 ± 2.17 per cent, respectively, in favor of the Maquiling area soils. It is further supported by the data for the acid-insoluble residue, it being in inverse relation to the sum of the acid-soluble soil constituents. A further study of the differences in averages of the sum of the acid-soluble and the acid-insoluble residue, as indicated in table 8, shows again that the Hawaiian soils, both the arid and humid, are weathered to a greater extent than the upland soils of the Maquiling area.

It may be also seen in table 8 that the Maquiling area soils, both lowland and upland soils, are significantly poorer in organic matter content than the Hawaiian soils.

SUMMARY AND CONCLUSION

1. The plant foods held in reserve in lowland and upland soils were determined by the use of 10 per cent HCl.

2. The chemical composition of the corresponding subsoils were in a similar manner analyzed and results given.

3. Compared with upland soils, lowland soils are highly weathered.

4. The amount of P_2O_5 and K_2O held in reserve in the surface and in subsoils are the same while nitrogen is higher in surface than in subsoils.

5. There is no significant difference in P_2O_5 and K_2O contents of lowland and upland surface soils. In the case of nitrogen it is higher in lowland than in upland surface soils.

6. The Maquiling area soils, both lowland and upland, are not so intensively weathered as the Hawaiian soils.

7. The Maquiling area soils contain lesser amounts of organic matter than the Hawaiian soils.

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TABLE 1

Chemical analysis of the 10 per cent HCl extract, loss on ignition, insoluble residue, nitrogen and organic matter of lowland surface soils [a]

SAMPLE NUMBER	1	2	3	4	5	6
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
SiO_2 sol. in HCl	0.35	0.43	0.56	0.38	0.37	0.49
SiO_2 sol. in Na_2CO_3 ...	3.15	3.22	4.30	3.22	3.26	3.50
Al_2O_3	9.40	10.09	11.55	10.80	11.10	10.40
Fe_2O_3	7.59	7.91	8.14	8.20	9.12	9.88
CaO	1.18	1.34	2.45	1.40	1.88	1.63
MgO	0.90	0.84	0.71	0.93	0.81	0.88
K_2O	0.13	0.09	0.05	0.10	0.12	0.13
Na_2O	0.12	0.20	0.19	0.18	0.20	0.16
P_2O_5	0.27	0.24	0.19	0.20	0.23	0.21
SO_3	0.16	0.16	0.22	0.18	0.13	0.11
Loss on ignition	16.45	11.92	12.49	12.13	13.25	12.78
Insoluble residue	60.21	64.24	59.84	62.03	60.08	60.12
Total	99.91	100.68	100.69	99.75	100.55	100.29
N	0.16	0.13	0.14	0.16	0.14	0.17
Organic matter	3.32	3.00	3.22	4.01	3.82	3.99

[a] Average of duplicate determinations and calculated on oven dry basis.

TABLE 2

Chemical analysis of the 10 per cent HCl extract, loss on ignition, insoluble residue, nitrogen and organic matter of upland surface soils [a]

SAMPLE NUMBER	7	8	9	10	11	12
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
SiO_2 sol. in HCl	0.43	0.43	0.12	0.16	0.22	0.41
SiO_2 sol. in Na_2CO_3 ...	2.37	2.50	2.31	2.61	2.43	2.53
Al_2O_3	5.05	5.53	4.90	6.67	7.41	6.46
Fe_2O_3	6.80	7.16	7.95	8.87	6.88	6.70
CaO	0.80	0.75	0.94	1.01	0.97	1.41
MgO	1.11	0.99	0.73	0.73	0.79	0.76
K_2O	0.21	0.20	0.19	0.20	0.17	0.23
Na_2O	0.13	0.19	0.21	0.21	0.20	0.19
P_2O_5	0.22	0.17	0.25	0.24	0.21	0.22
SO_3	0.20	0.18	0.20	0.21	0.17	0.18
Loss on ignition	11.15	10.51	11.19	10.33	10.84	10.41
Insoluble residue	73.21	72.02	71.04	70.01	69.14	70.93
Total	101.68	100.63	100.03	101.25	99.43	100.43
N	0.15	0.12	0.15	0.14	0.12	0.13
Organic matter	3.12	2.78	3.00	3.18	2.89	3.19

[a] Average of duplicate determinations and calculated on oven dry basis.

TABLE 3

Chemical analysis of the 10 per cent HCl extract, loss on ignition, insoluble residue, nitrogen and organic matter of lowland subsoil[a]

SAMPLE NUMBER	1	2	3	4	5	6
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
SiO_2 sol. in HCl	0.42	0.36	0.58	0.40	0.42	0.38
SiO_2 sol. in Na_2CO_3	3.01	3.69	4.24	3.24	4.20	4.10
Al_2O_3	10.05	12.09	13.60	11.60	12.33	10.59
Fe_2O_3	8.23	8.89	8.76	9.88	10.43	8.98
CaO	1.07	1.34	2.53	1.12	1.17	1.85
MgO	0.78	0.77	0.91	0.98	1.01	1.20
K_2O	0.11	0.15	0.06	0.12	0.09	0.11
Na_2O	0.22	0.23	0.18	0.20	0.13	0.18
P_2O_5	0.17	0.23	0.18	0.21	0.19	0.17
SO_3	0.18	0.16	0.21	0.13	0.10	0.16
Loss on ignition	11.23	10.23	11.38	10.97	11.78	10.45
Insoluble residue	62.93	62.02	57.18	62.01	59.03	62.50
Total	98.40	100.16	99.80	100.78	100.88	100.67
N	0.09	0.08	0.10	0.08	0.11	0.13
Organic matter	2.70	2.66	2.75	2.85	2.98	2.88

[a] Average of duplicate determinations and calculated on oven dry basis.

TABLE 4

Chemical analysis of the 10 per cent HCl extract, loss on ignition, insoluble residue, nitrogen and organic matter of upland subsoil[a]

SAMPLE NUMBER	7	8	9	10	11	12
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
SiO_2 sol. in HCl	0.61	0.42	0.32	0.39	0.32	0.59
SiO_2 sol. in Na_2CO_3	2.92	2.69	3.66	2.74	2.74	2.65
Al_2O_3	7.18	6.31	7.48	8.70	8.63	7.30
Fe_2O_3	7.86	8.49	8.25	9.51	8.70	7.51
CaO	0.79	1.12	1.03	1.21	1.07	1.39
MgO	0.93	1.11	1.09	0.88	0.97	0.65
K_2O	0.21	0.23	0.26	0.24	0.17	0.19
Na_2O	0.19	0.13	0.25	0.27	0.22	0.17
P_2O_5	0.20	0.24	0.22	0.28	0.25	0.19
SO_3	0.20	0.25	0.19	0.17	0.18	0.26
Loss on ignition	10.89	10.25	9.68	10.15	10.59	9.60
Insoluble residue	69.01	69.52	68.53	65.53	67.12	70.20
Total	100.99	100.76	100.96	100.06	100.96	100.70
N	0.11	0.11	0.09	0.13	0.10	0.10
Organic matter	2.87	2.78	2.62	3.16	2.73	2.68

[a] Average of duplicate determinations and calculated on oven dry basis.

TABLE 5

Average chemical analysis of lowland and upland soils with their corresponding subsoils

	LOWLAND		UPLAND	
	Surface soils	*Subsoils*	*Surface soils*	*Subsoils*
	per cent	*per cent*	*per cent*	*per cent*
SiO_2 sol. in HCl	0.43 ± 0.02	0.42 ± 0.02	0.30 ± 0.04	0.44 ± 0.04
SiO_2 sol. in Na_2CO_3..	3.44 ± 0.12	3.75 ± 0.14	2.47 ± 0.03	2.90 ± 0.11
Total SiO_2	3.87 ± 0.21	4.17 ± 0.15	2.77 ± 0.03	3.34 ± 0.10
Al_2O_3	10.55 ± 0.20	11.71 ± 0.35	6.00 ± 0.30	7.60 ± 0.22
Fe_2O_3	8.47 ± 0.24	9.13 ± 0.22	7.56 ± 0.24	8.39 ± 0.38
$Al_2O_3 + Fe_2O_3$	19.02 ± 0.36	20.84 ± 0.49	13.56 ± 0.37	15.99 ± 0.39
CaO	1.64 ± 0.12	1.51 ± 0.16	0.98 ± 0.02	1.10 ± 0.06
MgO	0.85 ± 0.02	0.94 ± 0.04	0.85 ± 0.05	0.94 ± 0.05
K_2O	0.10 ± 0.03	0.11 ± 0.01	0.20 ± 0.00	0.22 ± 0.01
Na_2O	0.18 ± 0.03	0.19 ± 0.01	0.19 ± 0.02	0.21 ± 0.01
Total base	2.77 ± 0.08	2.75 ± 0.17	2.22 ± 0.13	2.47 ± 0.02
P_2O_5	0.22 ± 0.03	0.19 ± 0.00	0.22 ± 0.03	0.23 ± 0.03
SO_3	0.16 ± 0.03	0.16 ± 0.01	0.19 ± 0.00	0.21 ± 0.03
Sum of the soluble Constituents	26.04 ± 0.53	28.11 ± 0.89	18.96 ± 0.48	22.24 ± 0.38
Loss on ignition	13.32 ± 1.47	10.01 ± 0.12	10.73 ± 0.10	10.19 ± 0.13
Insoluble residue ...	61.09 ± 0.15	60.94 ± 0.19	71.06 ± 0.13	68.31 ± 0.48
Total	100.45	100.36	100.75	100.74
N	0.15 ± 0.00	0.10 ± 0.00	0.14 ± 0.00	0.10 ± 0.00
Organic matter	3.56 ± 0.16	2.80 ± 0.03	3.02 ± 0.03	2.81 ± 0.03

TABLE 6

Showing differences in averages of the sum of the acid soluble soil constituents, acid insoluble residue, loss on ignition and of the principal plant foods

SOIL	SUM OF THE ACID SOLUBLE SOIL CONSTITUENTS	ACID INSOLUBLE RESIDUE	LOSS ON IGNITION	PRINCIPAL PLANT FOODS		
				N	P_2O_5	K_2O
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
L.[a] surface–U.[b] surface	7.00 ± 0.72 s[c]	9.97 ± 0.20 s	2.59 ± 1.48 i[d]	0.01 ± 0.00 s	0.00 ± 0.04 i	0.10 ± 0.04 i
L. surface–L. subsoil ..	2.07 ± 1.04 i	0.15 ± 0.20 i	3.31 ± 1.47 i	0.05 ± 0.00 s	0.03 ± 0.03 i	0.01 ± 0.03 i
U. surface–U. subsoil .	3.28 ± 0.67 s	2.75 ± 0.50 s	0.54 ± 0.16 s	0.04 ± 0.00 s	0.01 ± 0.04 i	0.02 ± 0.01 i
L. subsoil–U. subsoil ..	5.87 ± 0.97 s	7.37 ± 0.52 s	0.18 ± 0.18 i	0.00 ± 0.00 i	0.04 ± 0.03 i	0.11 ± 0.01 s

[a] L–means lowland.
[b] U–means upland.
[c] s–means significant.
[d] i–means insignificant.

TABLE 7

A comparison of the chemical analysis of Maquiling area soils with those of Hawaiian soils [a]

	HAWAIIAN		MAQUILING	
	Arid soils	*Humid soils*	*Upland soils*	*Lowland soils*
	per cent	*per cent*	*per cent*	*per cent*
SiO_2 sol. in HCl	0.63 ± 0.10	1.49 ± 0.33	0.30 ± 0.04	0.43 ± 0.02
SiO_2 sol. in Na_2CO_3 .	1.07 ± 0.13	0.49 ± 0.14	2.47 ± 0.03	3.43 ± 0.12
Al_2O_3	12.41 ± 1.17	13.72 ± 1.37	6.00 ± 0.30	10.55 ± 0.20
Fe_2O_3	11.15 ± 0.57	19.67 ± 2.95	7.56 ± 0.24	8.47 ± 0.24
TiO_2	0.22 ± 0.03	0.63 ± 0.16	———	———
Mn_3O_4	0.29 ± 0.08	0.10 ± 0.02	———	———
CaO	2.33 ± 0.86	0.31 ± 0.05	0.98 ± 0.02	1.64 ± 0.12
MgO	1.13 ± 0.29	0.29 ± 0.12	0.85 ± 0.05	0.85 ± 0.02
K_2O	0.05 ± 0.01	0.03 ± 0.01	0.20 ± 0.00	0.10 ± 0.03
Na_2O	0.20 ± 0.03	0.12 ± 0.05	0.19 ± 0.02	0.18 ± 0.03
P_2O_5	0.61 ± 0.16	0.01 ± 0.00	0.22 ± 0.03	0.22 ± 0.03
SO_3	0.22 ± 0.01	0.55 ± 0.16	0.19 ± 0.00	0.16 ± 0.03
Sum of the soluble constituents	30.31 ± 0.52	37.41 ± 2.10	18.96 ± 0.48	26.04 ± 0.53
Loss on ignition	20.20 ± 1.99	31.32 ± 2.12	10.73 ± 0.14	13.32 ± 1.47
Insoluble residue ...	50.08 ± 2.61	31.13 ± 1.94	71.06 ± 0.13	61.09 ± 0.15
Total	100.59	100.86	100.75	100.45
Organic matter	8.25 ± 0.75	11.02 ± 1.49	3.02 ± 0.03	3.56 ± 0.16

[a] The data for the Hawaiian soils were obtained from the Inaugural-Dissertation of Charles Richter 1933.

TABLE 8

Showing differences in average of the sum of the acid soluble soil constituents, acid insoluble residue and organic matter

SOILS	SUM OF THE ACID SOLUBLE SOIL CONSTITUENTS	ACID INSOLUBLE RESIDUE	ORGANIC MATTER
	per cent	*per cent*	*per cent*
L.[a] surface soils–H.[b] arid soils	4.27 ± 0.74 s [c]	11.01 ± 2.65 s	4.69 ± 0.90 s
L. surface soils–H. humid soils	11.37 ± 2.17 s	29.96 ± 1.99 s	7.46 ± 1.57 s
U.[d] surface soils–H. arid soils	11.35 ± 0.71 s	20.98 ± 2.64 s	5.23 ± 0.75 s
U. surface soils–H. humid soils	18.45 ± 2.18 s	39.93 ± 1.98 s	8.00 ± 1.49 s

[a] L–means lowland.
[b] H–means Hawaii.
[c] s–means significant.
[d] U–means upland.

A BIOLOGICAL STUDY ON SOME COMMON PHILIPPINE TERMITES[1]

GUILLERMO A. PANGGA

WITH SIXTEEN TEXT FIGURES

The peculiar modes of life of termites, the manner in which they conduct their social organization, the unique but effective ways by which they have solved their problems of personal relations, and the numerous other means by which this group of insects has successfully met otherwise puzzling situations have long been a favorite theme, not only of philosophical biologists, but also of literary men. Facilities for first-hand observation on termites in the Philippines are probably surpassed by few other countries, on account of our relatively large number of species, some forty of which are now known. Perhaps an equal number remain undiscovered. Moreover, damage to buildings, furniture, books, clothing, and other property as a result of the work of some of the forms and the important rôle played by all the rest as tropical soil-builders, would justify, from an economic point of view, whatever attempt may be made towards a more intensive study of our termite fauna.

Very little has been done on the biology of Philippine termites. Aside from random notes by travellers during the past centuries and fragmentary papers by naturalists, cited by Light (1921), a general paper by Uichanco (1919) on mound-building termites, a paper by Brown (1918) on termite mushrooms, and incidental field data entered by Oshima (1916, 1917, 1920) and Light (1921a, 1921b, 1929, 1930) in their systematic treatises, practically nothing has been done along these lines in the Philippines. Because of the difficulty of controlled rearing in all the forms and the inherent handicaps attendant in making a connected field observation for each particular species, biological work on termites must of necessity be restricted. The present work was therefore undertaken in the hope of adding a few shreds to the very slowly accumulating mass of information on this group of insects in the Philippines.

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[1] Thesis presented for graduation, 1936, with the degree of Bachelor of Agriculture from the College of Agriculture, No. 500; Experiment Station contribution No. 1127. Prepared in the Department of Entomology under the direction of Dr. L. B. Uichanco.

OBJECTS OF THE PRESENT WORK

The objects of the present study were: (*a*) to determine the composition of the colony in seven common species of Philippine termites; (*b*) to study the structure and architecture of their nests; and (*c*) to find out if Paris green dusted on to the bodies of termites can be used satisfactorily against the noxious forms.

TIME AND PLACE OF THE PRESENT WORK

The present work was conducted in the Department of Entomology, College of Agriculture, University of the Philippines, Laguna. Surveys were made in and around the College of Agriculture campus. The work was carried on from April, 1932, to February, 1936, a period covering about three years.

Species studied

The following species were considered in the present work.

Family Kalotermitidae
Cryptotermes nocens Light
Cryptotermes cynocephalus Light

Family Rhinotermitidae
Coptotermes vastator Light

Family Termitidae
Macrotermes gilvus (Hagen)
Nasutitermes luzonicus Oshima
Microcerotermes los-bañosensis Oshima
Hospitalitermes hospitalis (Haviland)

Termites' nests

Twenty-five hills of mound-building termites were located in different places on the College grounds. The nests of species which do not build mounds were collected and brought to the laboratory. Wood infested by *Cryptotermes* was collected from houses on the Campus and in the barrios of Los Baños.

Equipment

The following materials were used: (*a*) meter stick; (*b*) cotton and carbon bisulfide; (*c*) mattock hoe; (*d*) vials and eighty per cent alcohol; (*e*) DeVilbiss powder blower No. 36; and (*f*) Paris green.

Procedure

Photographs. A representative termitarium of each species studied, as well as a portion of the attacked materials, was photographed.

Measurement of nest. The height and the diameter in five equidistant horizontal planes from the base upward of each mound were taken. The average of the five diameter-measurements was taken as the mean diameter of the mound. The perpendicular distance from the base to the top represented its height. The same method was used in measuring the auxiliary nests of *Microcerotermes los-bañosensis* and *Nasutitermes luzonicus.* Because of the irregularity of the tunnel contours of *Macrotermes gilvus, Microcerotermes los-bañosensis, Coptotermes vastator* and *Nasutitermes luzonicus,* several width measurements were taken at random along the tunnels with the aid of a pair of dividers. The height was taken at several points.

Dissection of different nests. About two hours before dissecting the mounds of the mound-building termites, they were fumigated with carbon bisulfide on cotton pellets, which were introduced through holes made with a crowbar; the holes were subsequently plugged. Fumigation was necessary in order to facilitate examination and collection of the inhabitants. No previous treatment was made on the nests of other species.

Examination of inhabitants. The numbers of soldiers and workers were counted, either in the field or in the laboratory. Adult termites collected from swarms were examined as to number of males and females.

Tunnels of different species of termites. Tunnels of different species of termites were examined macroscopically, noting particularly their color and texture. The number of soldiers and of workers from every one hundred-centimeter-length was determined.

Test for cellulose and lignin. In testing for cellulose, the Alfred I. Cohn method was used. The reagent consists of 10 grams copper sulfate dissolved in 100 cc. water. Into this was added a solution of 5 grams potassium hydroxide in 50 cc. water. Then the precipitate formed was washed with water and pressed in cloth filter. The precipitate was dissolved in ammonium hydroxide. Samples taken from different portions of the nest were pulverized separately. Ten grams of each sample were put in an acid bottle and into it 100 cc. of the foregoing reagent were added. The solution was allowed to stand for seven days, and shaken from time to time. By decantation, the liquid was transferred to Petri dishes and treated with concentrated sulfuric acid. The formation of a jelly-like precipitate indicated the presence of cellulose.

Tollens' method was followed in testing for lignin. A solution of concentrated hydrochloric acid and phloroglucine was put in a test tube. The container was half-immersed in water and into it one gram of the material to be tested was introduced. When the solution turned red, it indicated the presence of lignin.

DISCUSSION OF RESULTS

Mound-building termite, Macrotermes gilvus

Description of the mound. Macrotermes gilvus is one of the most common mound-building species of termites in the Philippines. It builds mounds of varying sizes in the field, sometimes around tree trunks. The tops of the mounds assume a conical, rounded or dome shape. The base is usually broad (fig. 1). The tops are usually free from vegetation, although in rare cases they are completely covered with cogon or other grasses. The mean diameter (table 1) ranges from 52.7 cm. to 110.2 cm., with an average of 76.03 ± 6.31 cm. The height ranges from 46.3 cm. to 121.4 cm., with an average of 57.4 ± 5.09 cm.

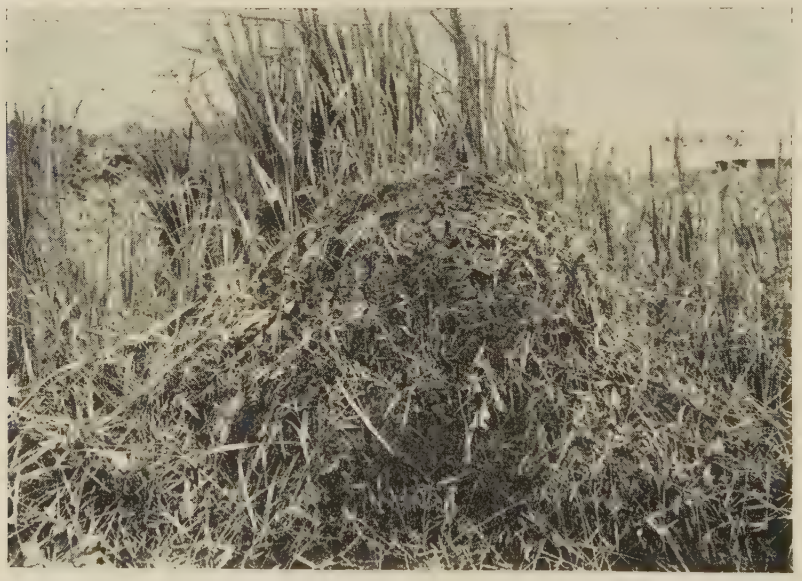

Fig. 1.—A mound of *Macrotermes gilvus* (Hagen)

The outer walls of the mounds were found to be invariably made of very fine clay, which was so compact that a very strong force was necessary to break it. The greater portion of the inner cavity of the mound (fig. 2) was occupied by the fungus garden. Each slab of the fungus garden was lodged in a niche, a series of which was hewn out of the central clayey pillar of the mound. Numerous passageways connected the different units. The garden slab itself (fig. 4) was composed of a group of thick-walled, irregularly-shaped cells. The upper surface was smooth and convex and the lower, concave and rugged, presumably for greater stability as it rested on the floor of the niche. Small, white globular bodies were found in the cells. These were the "buttons" of certain species of mushrooms, which appeared to be purposely cultivated by termites in the garden and used for food. According to Brown (1918), *Aegerita duthei* Berk. and *Xylaria*-like structures are the fungi found in the combs of termites around the vicinity of Manila and Los Baños. Digging the mound to a depth of about 10 to 30 cm. below the level of the ground, the writer found the royal chamber, which consisted of a cavity with a flat bottom and convex top (fig. 3), with thick irregular compact walls through which run numerous passageways for workers and soldiers. In the chambers were found the king and the queen, attended by a great mass of soldiers and workers.

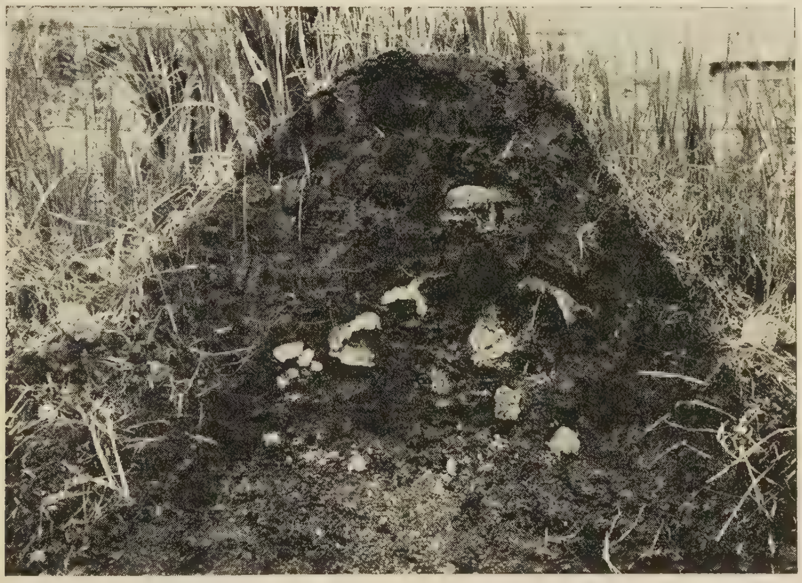

Fig. 2.—Vertical section of the mound in fig. 1.

Two queens were found in each of three out of five royal chambers examined. The queen may readily be identified because of her characteristic much distended abdomen. She can hardly move because of the weight of the eggs. Usually, the king easily escapes from the royal chamber when this is opened for examination so that sometimes he cannot be found. The soldiers are provided with large and powerful jaws. There are two kinds of soldiers and workers present in the colony, the large and small soldiers and the large and small workers. The soldier: worker coefficient (number of soldiers divided by number of workers in random samples) in the termitarium was 0.0971 ± 0.002.

The tunnel. Covered runways are built on living and dead trees, stumps, and even on unprotected posts and wooden superstructure of houses. The tunnels are flat, brown, and fragile. The outlines are very irregular, the width ranging from 10 to 20 mm. (average 13.57 ± 0.29 mm.) (table 2). The crests of the tunnels are slightly undulate, so that the height of tunnels varied from 4 to 8 mm., with an average of 5.8 ± 0.07 mm. Hard rain usually washes out the tunnels. Many tunnels were often found to run into each other and form a solid cover over the entire tree stumps in caiñgins. Counts made from 25 one hundred-centimeter lengths of tunnel gave a range of 5 to 14, with an average of 9.72 ± 0.50 soldiers, and 41 to 239, with an average of 124.52 ± 18.25 workers (table 2). The soldier: worker coefficient was 0.057 ± 0.008. Comparing this coefficient with that in the mound, the difference was 0.0398 ± 0.0001, indi-

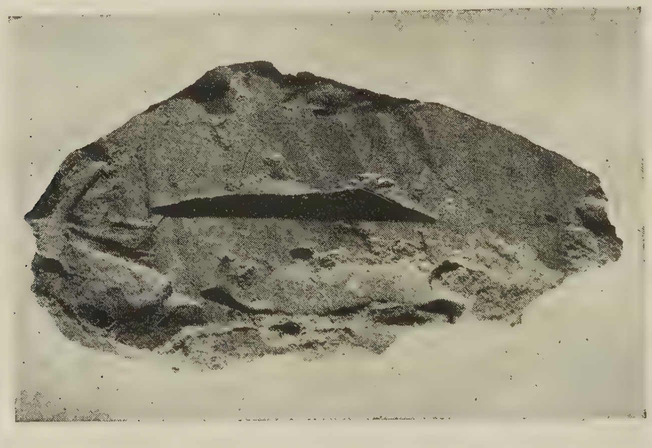

Fig. 3.—Vertical section of a royal chamber of *Macrotermes gilvus* (Hagen)

cating that there were significantly more soldiers in the mound than in the tunnels. These figures seem to indicate that, while soldiers accompany the workers in foraging, their more important function is to stay behind and protect the colony.

Composition of the mound and tunnel. Fine clay and lignin were present in the mound wall, to indicate probably that its component material was in part derived from termite excreta. Tests for lignin, moreover, showed its presence in all other parts of the mound. Cellulose was confined to the fungus garden, in combination with lignin. The probable explanation is perhaps that, in addition to excreta, the workers masticate wood and use it raw in making this structure. The tunnel is made of surface soil, and because lignin was also present, excreta must likewise form a part in its composition.

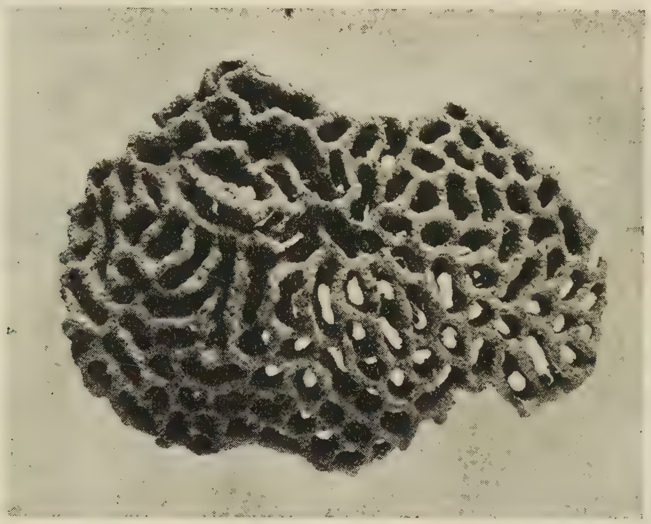

Fig. 4.—A slab of a fungus garden of *Macrotermes gilvus* (Hagen)

Swarming. Swarming was usually observed around Los Baños between the months of May and September (table 3), which period coincides with the rainy season in this vicinity. Swarming usually occurred from 6:55 p. m. to 4:50 a. m. (table 3). The average female ratio in the samples collected from the swarm was 0.4133 ± 0.0445 (table 3). It was also observed that the size of the swarm varied at different times, to indicate probably a regulatory influence of weather factors. Table 3 shows the average temperature and humidity seven days before swarming and on the day of swarming. The choice of seven days prior to swarming was arbitrary and was thought probably to represent weather conditions when no swarming was taking place. It may be seen from the table that the average temperature seven days before swarming was 28.3 ± 0.16°C. and on the day of swarming, 27.9 ± 0.58°C. The insignificant difference of 0.4 ± 0.60°C. shows that apparently temperature had no important determining influence. The average relative humidity, seven days before swarming, was 74.71 ± 0.0438 per cent and on the day of swarming, 77.21 ± 0.7459 per cent. The difference was 2.50 ± 0.7471, which probably shows a more significant rôle of atmospheric humidity in swarming. One important point observed was that the occurrence of the swarm was usually preceded by a light rain either early in the evening of the swarming or just a few hours before swarming.

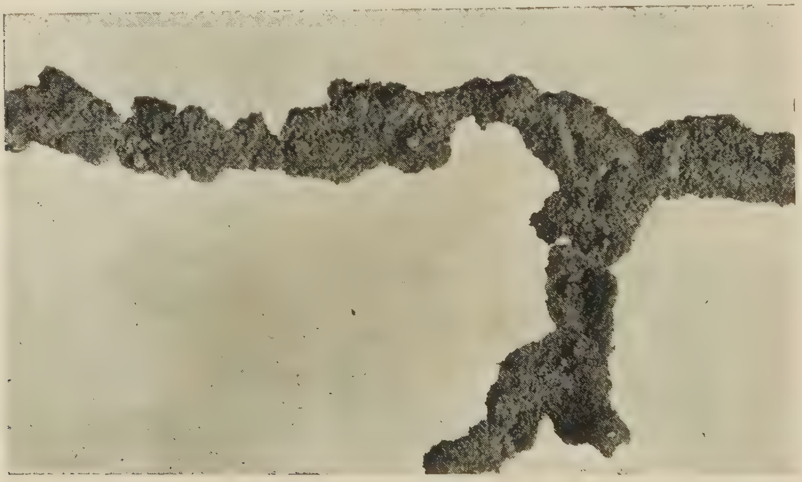

Fig. 5.—A portion of a tunnel of *Macrotermes gilvus* (Hagen)

Microcerotermes los-bañosensis

Location of the nest. This species of termites was commonly met with making an auxiliary nest on the surface of the ground, and occasionally on the base of tree stumps (fig. 6), around posts and even on the beam of the buildings. Measurements of twenty-five auxiliary nests are shown in table 1. The diameter of the auxiliary nests varied from 19.2 to 33.6 cm., with an average of 24.1 ± 0.52 cm. The heights ranged from 16.2 to 51.5 cm., with an average of 28.4 ± 1.19 cm.

Description and composition of the nest. The shape of the auxiliary nest is variable. It may be conical, oval, or sometimes round.

It is hard, more or less brittle and, when dissected, shows a honeycomb-like arrangement of chamber. The top is always free from green vegetation, because of the absence of an investing clay wall. It was observed in caiñgin fields that when the tree stump to which a nest was attached was burned, the nest was also reduced to ashes. The auxiliary nest consists mainly of cellulose, lignin and soil. The outside wall is rough and is fairly compact, protecting the inner parts from light.

Occupants. Workers and soldiers were found in the auxiliary nest. The king and queen were not found in the nests examined. The soldier:worker coefficient in the auxiliary nest was 0.1125 ± 0.02 (table 1).

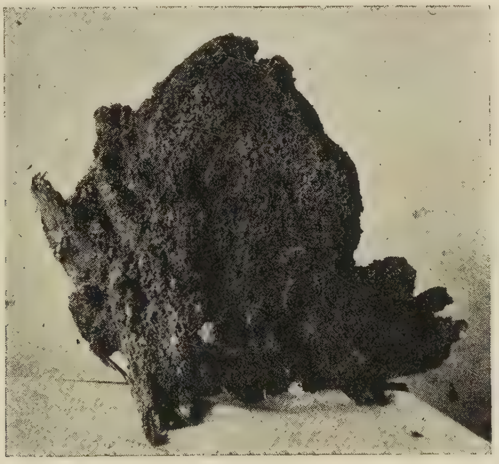

Fig. 6.—Auxiliary aërial nest of *Microcerotermes los-bañosensis* Oshima built on tree stump.

Description of the tunnel. Tunnels of *Microcerotermes los-bañosensis* are very common on both living and dead trees. Tunnels originate from the ground and extend up to the uppermost part of the trees. This species of termites often overruns houses on the Campus where it builds tunnels from the posts to the roofs. The tunnels are slender, brown, and hard (fig. 7). They are more or less tubular, with the base at point of attachment flattened. The general outline is not as irregular and the size not as large as the tunnel of *Macrotermes gilvus.* Measurements taken at random along the tunnel showed a width range of 4 to 6 mm., with an average of 4.73 ± 0.21 mm., and the height range from 4 to 5 mm., with an average of 4.34 ± 0.03 mm.

In the tunnel the number of soldiers from each one-hundred-centimeter length of tunnel varied from 1 to 2 with an average of 1.2 ± 0.07, workers from 8 to 106 with an average of 32.4 ± 3.85 (table 2). The soldier:worker coefficient was 0.043 ± 0.005. Comparing the coefficient in the nest with that of the tunnel, it will be seen that there were significantly more soldiers in the nest than in the tunnels as shown by the difference of 0.0689 ± 0.004.

Coptotermes vastator

Of all the termite species reported in this paper, *Coptotermes vastator* was the most common species that the author found destructive. According to Light (1929), about 90 per cent of the damage done to woodwork, timbers, furniture and other materials that is in contact with the ground in the Philippines is due to this species.

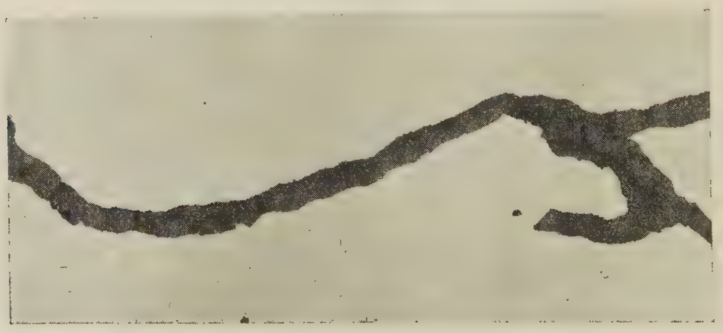

Fig. 7.—A portion of a tunnel of *Microcerotermes los-bañosensis* Oshima

Location of the nest. This species of termites does not build exposed nests, but apparently locates them deep under the surface of the ground. However, usually auxiliary nests, which contain no reproductive individuals, are often found inside infested wood. Attempts made to follow the subterranean nest by digging one and one-half meters deep below the spot of infestation have failed, although its location somewhere in the neighborhood of the excavation was indicated by the issuance of foraging bands of workers and soldiers.

Habits and damage to building. Coptotermes vastator seems to avoid humid places. Most of the specimens of this species were collected by the author on house posts, joists, and other parts inside the building, and on dead tree stumps exposed to sunshine. Not a single specimen was collected from moist locations.

The presence of this termite in posts and other parts of the building is hard to detect. The work is hidden so that the attacked parts may collapse before their presence is discovered. The workers make continuous longitudinal excavation in the wood (fig. 9), leaving the outer portion intact. The attacked wood appears perfectly sound. In advanced stages of infestation, however, tunnels begin to appear on the surface of the wood, at a time when nothing can be done to save the material, and the infested parts can only be replaced with new ones. The greater portion of the infested material is hollow and in the cavities are found the auxiliary paper-like nests (fig. 8). These auxiliary nests are made of excreta of the insect, hard but brittle, and light brown in color. The main constituents of the nest were found to be cellulose and lignin. Old auxiliary nests in the wood were usually found empty, the occupants having apparently deserted them for a more promising, less exploited location.

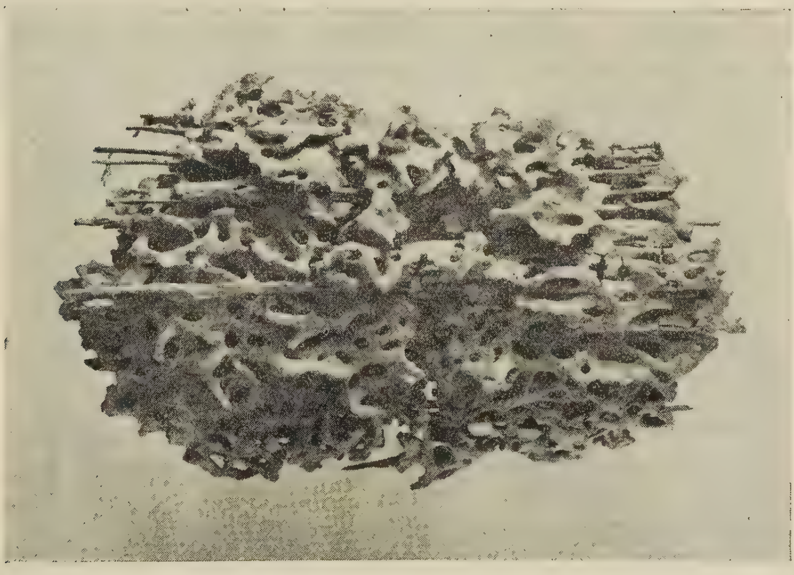

Fig. 8.—A portion of an auxiliary aërial nest of *Coptotermes vastator* Light

This species of termites begins infestation on parts of the material that come in contact with the ground and works its way upward. It even passes through minute cracks of the cement foundation. Figure 10 shows some pamphlets severely damaged by this termite. These pamphlets were piled on a cement floor. The cement floor below the pile had cracked slightly and the presence of the termites was noticed after it was almost too late to save the papers.

Description of the tunnel. *Coptotermes vastator* was seldom observed to make covered runways over non-woody structures. The tunnel is yellowish brown, fragile, and more or less irregular in general outline (fig. 11). The width was found to range from 6 to 12 mm., with an average of 7.78 ± 0.34 mm. (table 2). The height varied from 4 to 5 mm., with an average of 4.1 ± 0.02 mm. The main constituents of the tunnel were found to be cellulose and lignin.

Coefficient of soldiers to workers. Counts made of inhabitants of the auxiliary nest in the infested wood, showed that the soldier: worker coefficient was 0.1004 ± 0.014. In the tunnels the number of soldiers from every one-hundred-centimeter length of tunnel ranged from 5 to 10, or an average of 7.5 ± 0.70; workers 28 to 118, or an average of 71.8 ± 13.27. The coefficient of soldiers to workers was 0.1305 ± 0.0189 (table 2). Comparing the coefficient of soldiers to workers in the nest with that of the tunnel, it will be seen that there were significantly more soldiers in the tunnel as shown by the difference of 0.0301 ± 0.0006.

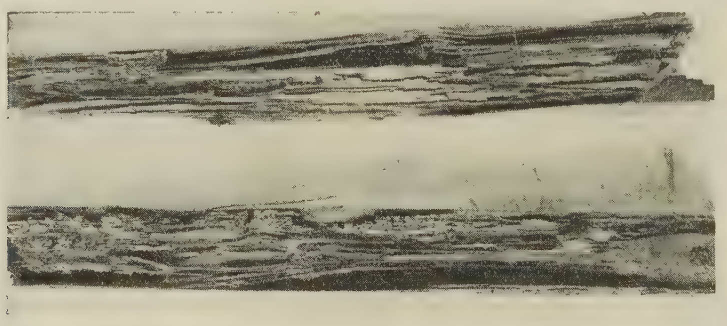

Fig. 9.—Work of *Coptotermes vastator* Light in wood

Dry-wood termites

Species and their food. There are two species of dry-wood termites known in the Philippines, *Cryptotermes cynocephalus* Light and *Cryptotermes nocens* Light. These species of termites are found on dry, but not decaying, wood, and in the present investigations were noted usually to live together in the same galleries, so that no separate observation could be made for each. A survey made showed that most of the lumber infested was apitong, which is a low grade of wood, belonging to the third group by Bureau of Forestry classification. The material of this species of termites was obtained from infested pieces of wood found during the process of repairing houses or buildings.

Nature and appearance of colonies. The best indications of the presence of dry-wood termites is the presence of fecal pellets thrown out from their galleries in the wood. These pellets accumulate on the floor, especially in the corners. The infested wood and the location of the galleries can be detected by the hollow sound of the wood upon tapping it with a hammer. A normal wood gives a higher pitch than the attacked.

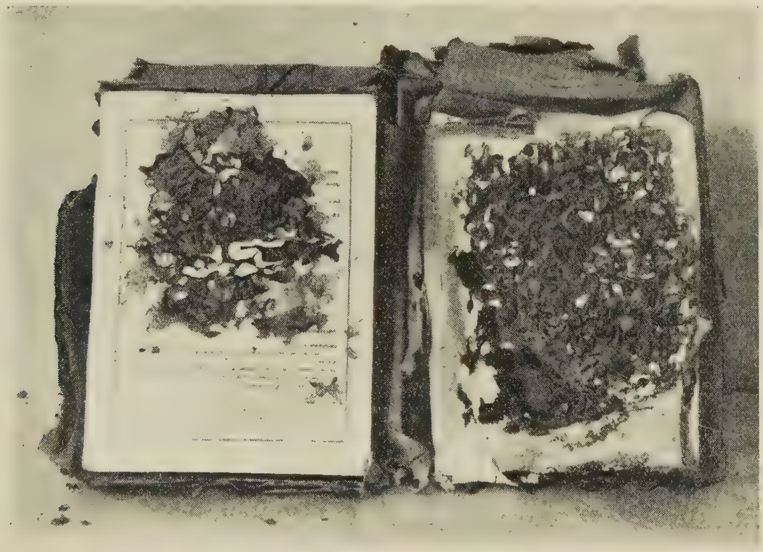

Fig. 10.—Papers destroyed by *Coptotermes vastator* Light

Longitudinal sections of the wood infested by dry-wood termites are shown in figures 12 and 13. The excavation made by termites is not continuous. Termites eat through the wood longitudinal galleries of limited lengths. Table 4 shows the measurement of the galleries made by termites. The length, width and the thickness of the galleries were found to be extremely variable. In severe cases the galleries usually approached the surface of the wood, leaving a parchment-like outer layer, through which here and there are tiny holes, probably for elimination of excretal pellets. Usually, a transverse, small round hole having a diameter of about one millimeter served as communicating passage from one gallery to the other. On dissection of wood infested by *Cryptotermes,* it was found that the colony consisted largely of nymphs, which took the place of workers. The nymphs were of different stages, some having wing pads. The coefficient of soldiers to nymphs was 0.012 ± 0.001 (table 4).

In wood infested by dry-wood termites, sometimes winged adults were found. Usually wingless adults were noted in the infested wood. These probably represented the queens and kings of dry-wood termites, although the females showed no marked distension in the abdomen.

Swarming was usually observed in the month of May, or at about the end of the dry season. The average temperature seven days before swarming was 27.8 ± 0.45°C. and on the day of swarming 27.69 ± 0.11°C. (table 3). The difference, 0.1 ± 0.46°C. is very insignificant. The relative humidity seven days before swarming was 75.99 ± 1.71 per cent and during swarming, 77.33 ± 1.84 per cent. Although the relative humidity on the days of swarming was somewhat higher than on any of the seven days before swarming, the difference (1.33 ± 2.5) was insignificant indicating that both temperature and relative humidity had no important determining influence on swarming. The mean female ratio in swarms was 0.4209 ± 0.0077.

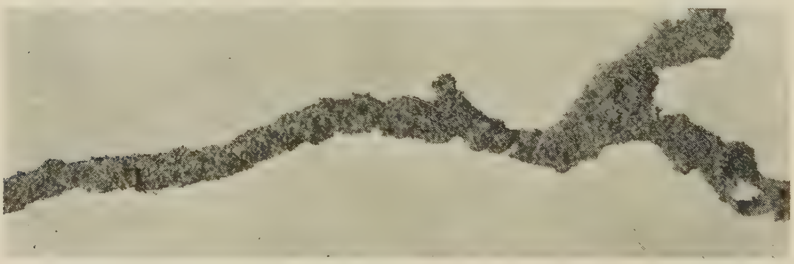

Fig. 11.—A portion of a tunnel of *Coptotermes vastator* Light

Nasutitermes luzonicus Oshima

Location of the nest. This species of termites is a common builder of conspicuous auxiliary nests at the bases of trees, trunks, especially coconut, and stumps (fig. 14). It was observed that this species never built its auxiliary nest in contact with the surface of the ground, unlike *Microcerotermes,* which builds its auxiliary nest on the ground at the base of tree stumps.

Description of the auxiliary nest. The auxiliary nest is very irregular in outline and approaches an oval shape. It is brown, and when dissected, the interior showed a honeycomb-like construction. It resembles superficially the nest of *Microcerotermes los-bañosensis* Oshima. Upon close examination, however, the nest is softer and less compact than that of the *Microcerotermes*. Measurements of the nests are shown in table 1. The diameter ranged from 9.6 to 17.3 cm., the average being 13.7 ± 1.07 (table 1). The height ranged from 4.3 to 9.5 cm., with an average of 7.14 ± 0.84 cm.

The main constituents of the nest were soil, cellulose, and lignin.

Tunnels of these species are very common on living and dead trees. They are brown, flat and hard (fig. 15). The width of the tunnel ranged from 7 to 16 mm., with an average of 10.56 ± 0.29 cm., and the height ranged from 4 to 6 mm., with an average of 4.5 ± 0.04 mm. In the old tunnel, cracks could be seen on the surface. The main constituents of the tunnel are soil, lignin, and cellulose.

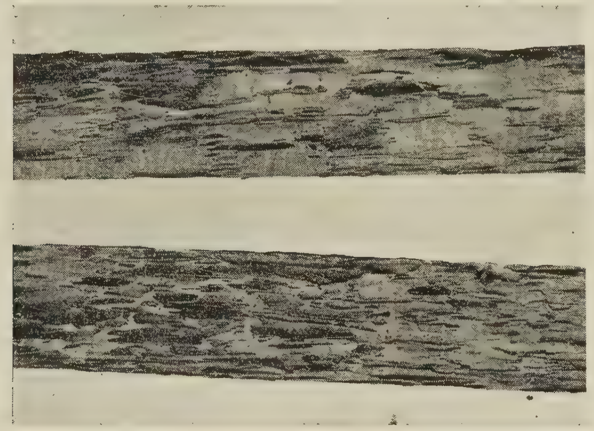

Fig. 12.—Work of *Cryptotermes* spp. in wood

In the five auxiliary nests dissected neither king nor queen was found. The soldiers present anterior projection of the head described as "nasute." Both soldiers and workers are brownish in color, the soldiers being the darker. The soldier : worker coefficient in samples taken from the nest was 0.1209 ± 0.013. In the tunnels the soldier : worker coefficient was 0.2512 ± 0.0434. The difference between the soldier : worker coefficient in the auxiliary nest and that in the tunnels was 0.0789 ± 0.002.

Hospitalitermes hospitalis

Habits. This species of termites was found to travel in the open on the surface of the ground and on trees without any protective tunnels. No complete nest could be located in the present work, but years ago an entomology student succeeded in digging out a colony, with a queen, from under a tree trunk.[2] A fragment of a nest found by the writer under a tree trunk showed that the nest is made of dark brown soil, cellulose, and lignin.

Workers and soldiers were found to travel a considerable distance, as much as twenty-five meters having been traced. Places covered by grass were preferred. Heat of the sun may be one of the factors that affect the duration of the travel. In the forest where the ground is shaded by trees, it was found that they traveled the whole day, while in the exposed places open foraging ceased when the sun rays grew warm enough to dry the dew. Usually the workers were found to carry small pellets in their jaws. This was found to be a certain species of fungi, which the termites possibly utilize for food.

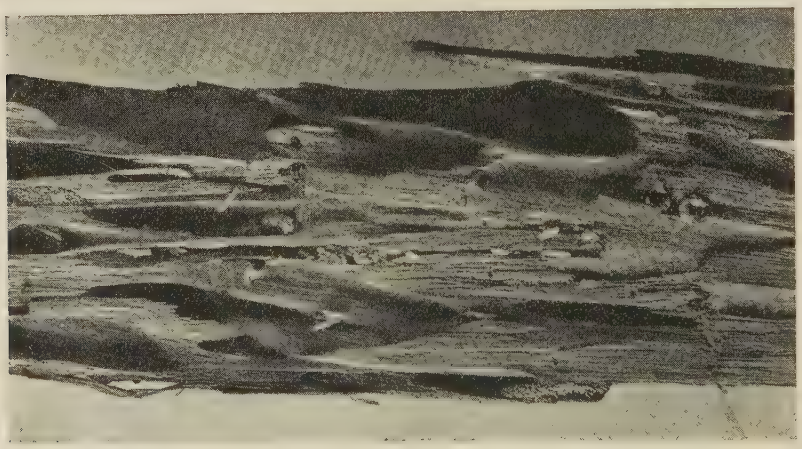

Fig. 13.—A dissected portion of wood showing details of galleries of *Cryptotermes* spp.

Both soldiers and workers are dark brown, the soldiers being "nasute." The queen is darker and has a distended abdomen. The soldier: worker coefficient in the sample collected from travelling bands was 0.1099 ± 0.0013 (table 1).

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[2] Information obtained through the courtesy of Dr. L. B. Uichanco.

CONTROL

Treatment of dry wood termites. The discovery of trophallaxis, or exchange of nourishment, in social insects by Professor William Morton Wheeler, of Harvard University, whereby individuals of the colony lick one another's bodies, has been taken advantage of in recent years in termite control. Paris green or other poison dusts applied on the bodies of workers and soldiers of termites are brought by these into the nest and eaten by the other members of the colony as a result of their trophallactic habits (Smith, 1930). Hence, the entire source eventually is destroyed by a relatively simple and inexpensive process. In the present work using a DeVilbiss powder blower No. 36, Paris green was dispersed through a small deep hole bored with an electrician's auger into wood infested by dry wood termites. The results of the tests are shown in table 5. Of the twelve treatments made, only one showed living termites twenty-four days after treatment. This one failure was found to be due to the hole which was not deep enough to reach the galleries and hence the poison dust did not come in contact with the termites.

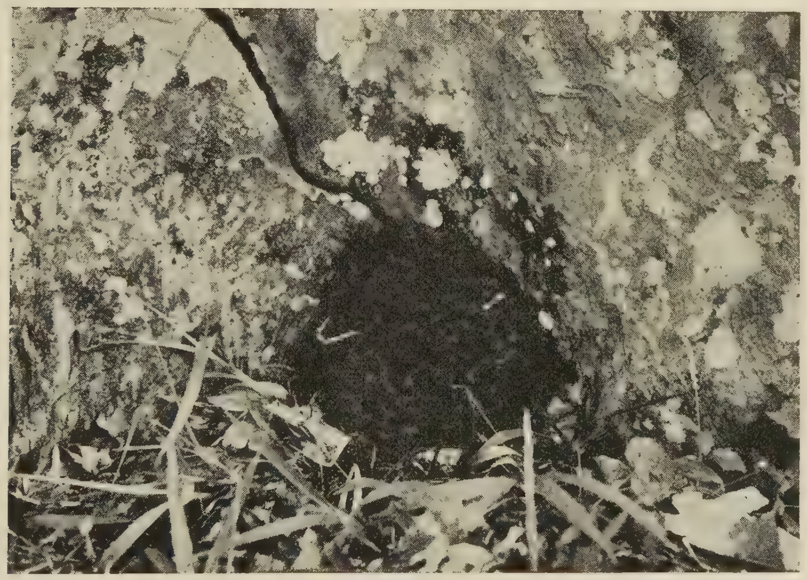

Fig. 14.—Auxiliary aërial nest of *Nasutitermes luzonicus* Oshima built on a large tree trunk

Field tests on four species of termites. The effect of Paris green dust was also tried in controlling subterranean species of termites.

The dust was injected into the nests, tunnels, stumps and other infested materials with the DeVilbiss powder blower. The results of the treatment are shown in table 6. It may be seen from these tables that Paris green also gave encouraging results in controlling subterranean termites. Examination made daily until the occupants in the treated lots have either been killed or have disappeared showed that it took one to twenty-two days to completely free the infested structures.

Buildings infested by termites. In the course of this work, the author was requested to treat a number of building of the College of Agriculture which were infested by termites. The names and the parts of the buildings infested are shown in table 7. Door jambs were the parts most commonly attacked. This is because this part of the building came in contact with the ground in the College buildings worked on

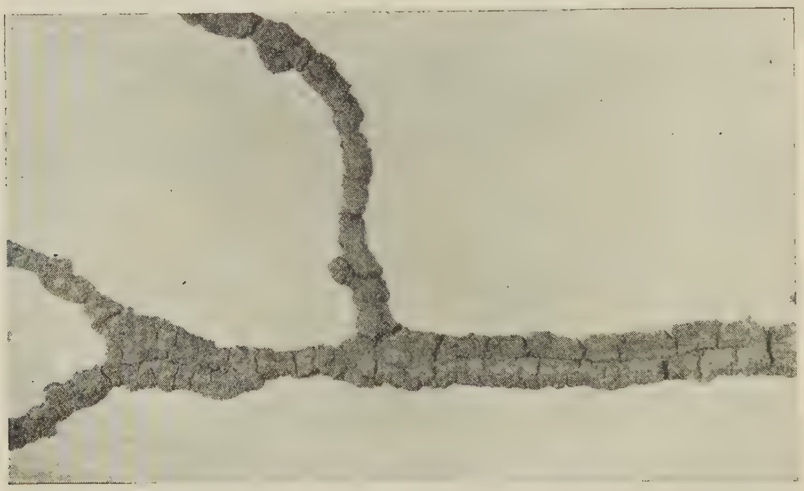

Fig. 15.—A portion of a tunnel of *Nasutitermes luzonicus* Oshima

Macrotermes gilvus disappeared from 1 to 14 days after treatment. Two trials with *Microcerotermes los-bañosensis* with the treatment of Paris green showed that the termites had disappeared in these tunnels in from 11 to 14 days after treatment. At this time when this paper is being written, about 5 months since the last inspection, the parts had not been reinfested, although regular periodic inspection is necessary, inasmuch as these buildings are structurally open to invasion from many sources by subterranean termites. The complete disappearance of *Cryptotermes* could not be determined definitely, because the parts treated are still intact on the buildings. However, judging from the absence of the usual accumulation of fecal pellets, it seemed that they were also under control.

SUMMARY AND CONCLUSIONS

1. The termites studied were *Macrotermes gilvus* (Hagen), *Microcerotermes los-bañosensis* Oshima, *Coptotermes vastator* Light, *Nasutitermes luzonicus* Oshima, *Cryptotermes nocens* Light, *Cryptotermes cynocephalus* Light, and *Hospitalitermes hospitalis* (Haviland).

2. Of the seven species considered, only two, *Cryptotermes nocens* and *C. cynocephalus* (Kalotermitidae) are a dry-wood form and, therefore, had no ground communication. The whole colony lives in galleries which the insects eat out in wood, apitong lumber being the most susceptible.

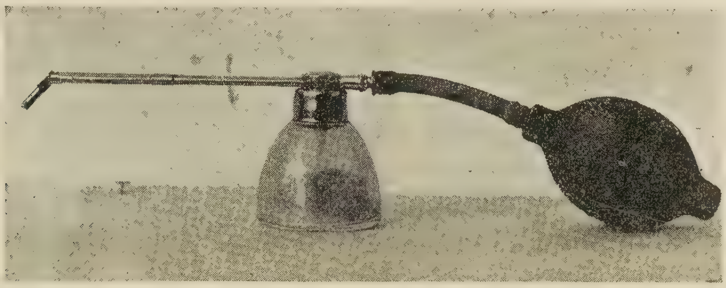

Fig 16.—DeVilbiss powder blower No. 36, with adjustable tip

3. The termitaria of the other five species are set in the ground, that of *Macrotermes gilvus* (Termitidae) being the most conspicuous, because it takes the form of a mound of considerable size, averaging in the present work 57.4 centimeters in diameter and 76 centimeters in height. The wall of this mound is hard and compact, serving as an effective protection from invasion by enemies, of which the most serious are the various species of ants, and from extremes of heat, dryness, and moisture. The king and queen are located in a specially constructed royal chamber set at about 10 to 30 centimeters below the surface of the ground. Moreover, this is the only species among those studied that cultivated mushrooms in an especially constructed fungus garden, representing in this respect apparently the highest type of organization in termite colonial life. Other species,

such as *Hospitalitermes hospitalis*, apparently depend on wild sources, where the fungi are gathered during foraging expeditions.

4. The subterranean nests of *Coptotermes vastator* (Rhinotermitidae). and of *Nasutitermes luzonicus*, *Microcerotermes los-bañosensis*, and *Hospitalitermes hospitalis* (all of the family Termitidae) could not be located, although their presence at some depth under the ground is indicated by the issuing bands of workers and soldiers. The first three species, however, build what are probably auxiliary nests, which contain no reproductive individuals, *Coptotermes* inside cavities of wood which the workers had eaten out, *Microcerotermes*, a large subglobular mass at the bases of tree trunks and stumps in contact with the ground, and *Nasutitermes*, a shapeless structure set on trunks and stumps, at a little distance up from the surface of the ground.

5. *Hospitalitermes hospitalis* is remarkable in that the workers and soldiers march in broad daylight, without any protective tunnel. *Macrotermes*, *Microcerotermes*, *Nasutitermes* and *Coptotermes* build tunnels, which in shape, structures, and dimensions are characteristic for each species. *Coptotermes* appears to be the least prone to build tunnels among the tunnel-building forms.

6. Among the subterranean species considered, earthen material doubtless enters largely in the construction of tunnels, and at least in *Macrotermes gilvus*, of the termiteria as well. The presence of lignin in all of their structures also shows that apparently excreta are used either pure, in some of the parts, or in admixture with earth, perhaps as a binder. In all, except in *Macrotermes*, moreover, cellulose was present in the nests and in the tunnels, indicating that wood was masticated and used in construction, rather than for food, probably to give body to the walls. In *Macrotermes* cellulose was found together with lignin only in the fungus garden, its fabrication out of triturated wood in fact being apparent even without chemical examination.

7. The soldier : worker coefficient in the tunnels of subterranean species ranged from 0.04 in *Microcerotermes los-bañosensis* to 0.2 in *Nasutitermes luzonicus*. The fact that the ratio increased considerably in the termitaria in *Macrotermes gilvus* would seem to indicate that, while soldiers accompany workers in foraging expeditions, a more important part of their functions is to stay home and protect the main colony. This possibly holds true also for the auxiliary nests in *Microcerotermes los-bañosensis*, to which these structures probably

mean more than to either *Coptotermes vastator* or *Nasutitermes luzonicus*. In the latter two species, the soldier : worker coefficient in the auxiliary nests is less than in the tunnels.

8 *Cryptotermes* has no worker caste, its place being taken by the nymphs which subserve its function prior to emergence to the adult stage. Because *C. nocens* and *C. cynocephalus* usually were found together in the same galleries, no separate data could be recorded for each of the two. The soldier : nymph coefficient was 0.012 ± 0.0013. The primitive nature of these termites is further shown by the fact that the reproductive females are not the specialized individuals with distended abdomen that are met with in subterranean termites but, except for the loss of wings, remain practically unchanged from the swarming adults.

9. Nuptial flights in and around Los Baños occurred between 7:00 p. m. and 5:00 a. m., most of them toward the end of the dry season, in May, in *Cryptotermes*, and from May to September, during the rainy season, in *Macrotermes gilvus*. Humidity, which is then somewhat higher, apparently plays an important part in determining the issuance of swarms of *Macrotermes gilvus*, while temperature probably has only a subordinate rôle. The data with these two physical factors are not conclusive in the case of *Cryptotermes*.

10. The average female ratio in *Macrotermes* swarms is 0.4137 ± 0.0184, which approaches the theoretical ratio of 0.5 for amphigonous insects. It is probably an indication that quite as many females as males in the maternal zygotes become converted into sterile soldiers and workers. This premise is further supported by the female ratio of 0.4209 ± 0.0077 in *Cryptotermes*, in which there are only a few soldiers and no workers produced. The difference in the female ratio for the two forms is 0.0076 ± 0.045, which is insignificant.

11. Limited trials with Paris green dusted on to the bodies of termites with a powder blower give promise of effective control of the noxious Philippine forms by taking advantage of their trophallactic habits.

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TABLE 1

Measurements and composition of nests and ratio of soldiers to workers in the termitaria

SPECIES	NUMBER OF NESTS EXAMINED	DIMENSIONS OF NESTS					
		DIAMETER			HEIGHT		
		Min.	Max.	Average	Min.	Max.	Average
	cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
Macrotermes gilvus	25	52.7	110.2	76.03 ± 6.3133	46.3	121.4	57.4 ± 5.0924
Microcerotermes los-bañosensis [a]	25	19.2	33.6	24.1 ± 0.5194	16.2	51.5	28.4 ± 1.1938
Coptotermes vastator [a]	5	—	—	—	—	—	—
Nasutitermes luzonicus [a]	25	9.6	17.3	13.7 ± 1.0724	4.3	9.5	7.14 ± 0.8363
Hospitalitermes hospitalis [b]	—	—	—	—	—	—	—

SPECIES	NUMBER OF NESTS EXAMINED	COMPOSITION OF TERMITARIA				SOLDIER: WORKER COEFFICIENT
		CELLULOSE		LIGNIN		
		Present (+) or absent (—)	Location	Present (+) or absent (—)	Location	
Macrotermes gilvus	25	+	fungus garden only	+	in all parts of termitarium	0.0971 ± 0.0020
Microcerotermes los-bañosensis [a]	25	+	in all parts of termitarium	+	*ditto*	0.1125 ± 0.0205
Coptotermes vastator [a]	5	+	*ditto*	+	*ditto*	0.1004 ± 0.0139
Nasutitermes luzonicus [a]	25	+	*ditto*	+	*ditto*	0.1209 ± 0.0135
Hospitalitermes hospitalis [b]	—	—	—	—	—	0.1099 ± 0.0013

[a] Observations confined to auxiliary nest, owing to failure to locate subterranean termitaria.

[b] On tree trunk where the termites issue from the ground.

TABLE 2

Measurements and composition of tunnels and counts of termites in every one-hundred centimeter length of tunnel

SPECIES	NUMBER OF TUNNELS EXAMINED	WIDTH OF TUNNEL			NUMBER OF MEASUREMENTS	HEIGHT OF TUNNEL		
		Min.	Max.	Average		Min.	Max.	Average
		mm.	*mm.*	*mm.*		*mm.*	*mm.*	*mm.*
Macrotermes gilvus	25	10	20	13.57 ± 0.2967	100	4	8	5.8 ± 0.0742
Microcerotermes los-bañosensis	25	4	6	4.73 ± 0.2090	100	4	5	4.3 ± 0.0324
Coptotermes vastator	5	6	12	7.78 ± 0.3439	100	4	5	4.1 ± 0.0236
Nasutitermes luzonicus	25	7	16	10.56 ± 0.2900	100	4	6	4.5 ± 0.0432

SPECIES	NUMBER OF TUNNELS	COMPOSITION OF TUNNELS			
		Cellulose		Lignin	
		Present (+) or absent (—)	Location	Present (+) or absent (—)	Location
Macrotermes gilvus	25	—	in all parts of tunnel	+	in all parts of tunnel
Microcerotermes los-bañosensis	25	+	*ditto*	+	*ditto*
Coptotermes vastator	5	+	*ditto*	+	*ditto*
Nasutitermes luzonicus	25	+	*ditto*	+	*ditto*

SPECIES	NUMBER OF TUNNELS	NUMBER OF TERMITES IN ONE HUNDRED-CENTIMETER LENGTHS OF TUNNEL								SOLDIER : WORKER COEFFICIENT
		Soldier				WORKER				
		Min.	Max.	Average	Total	Min.	Max.	Average	Total	
Macrotermes gilvus	25	5	14	9.72 ± 0.4991	243	41	239	124.52 ± 18.2452	3,113	0.0573 ± 0.0084
Microcerotermes los-bañosensis	25	1	2	1.2 ± 0.0708	18	8	106	32.4 ± 3.8513	810	0.0436 ± 0.0054
Coptotermes vastator	5	5	10	7.5 ± 0.7014	30	28	115	71.8 ± 13.2741	287	0.1305 ± 0.0189
Nasutitermes luzonicus	25	10	53	17.8 ± 1.9695	446	35	122	75.3 ± 3.7704	1,883	0.2512 ± 0.0434

TABLE 3

Counts of male and female termites collected from swarms in different months of the year

Macrotermes gilvus

NAME OF COLLECTOR	DATE	PLACE	TIME	MEAN TEMPERATURE		MEAN HUMIDITY	
				Seven days before the swarming	During swarming	Seven days before the swarming	During swarming
				°*C.*	°*C.*	*per cent*	*per cent*
L. B. Uichanco ...	29 - VI - 1932	Los Baños, P. I.; Elev. 85 m.	4:45 a.m.	29.57	28.00	73.62	75.33
A. Y. Coronel	21 - VII - 1933	" " " " " 50 m.	4:50 a.m.	28.29	28.5	76.72	67.66
G. A. Pangga	26 - VII - 1933	" " " " " " "	7:25 p.m.	28.00	26.5	73.76	81.00
J. Pandialan	26 - VII - 1933	" " " " " " "	8:10 p.m.	28.00	26.5	73.76	81.00
G. A. Pangga	3 - VIII - 1933	" " " " " " "	7:15 p.m.	26.29	27.5	78.57	80.00
E. B. Ramos	3 - VIII - 1933	" " " " " " "	8:30 p.m.	26.29	27.5	78.57	80.00
F. N. Salcedo	11 - VIII - 1933	" " " " " " "	8:00 p.m.	27.00	29.5	78.05	72.00
G. A. Pangga	9 - V - 1934	" " " " " " "	7:20 p.m.	29.00	29.0	67.43	69.33
G. A. Pangga	6 - VI - 1934	" " " " " " "	7:30 p.m.	29.07	29.25	73.05	69.33
G. A. Pangga	10 - VI - 1934	" " " " " " "	7:40 p.m.	28.82	27.0	71.95	75.00
A. P. Cacayan	17 - IX - 1934	" " " " " " "	7:45 p.m.	27.11	28.5	78.86	79.33
G. A. Pangga	25 - V - 1935	" " " " " " "	6:55-7:30 p.m.	29.54	27.25	74.85	85.33
G. A. Pangga	18 - VI - 1935	" " " " " " "	7:35-8:30 p.m.	29.79	28.5	70.81	78.33
G. A. Pangga	19 - VI - 1935	" " " " " " "	7:30 p.m.	29.61	28.0	71.81	79.33
G. A. Pangga	12 - VII - 1935	" " " " " " "	7:00 p.m.	28.29	26.5	75.24	86.33
G. A. Pangga	16 - VII - 1935	" " " " " " "	7:15 p.m.	28.05	28.75	78.35	76.00
		Average		28.3 ± 0.1686	27.9 ± 0.5801	74.71 ± 0.0438	77.21 ± 0.7459

Cryptotermes spp.

NAME OF COLLECTOR	DATE	PLACE	TIME	Seven days before the swarming	During swarming	Seven days before the swarming	During swarming
G. A. Pangga	9 - V - 1934	Los Baños, P. I.; Elev. 50 m.	7:20 p.m.	29.00	29.0	67.43	69.33
G. A. Pangga	21 - V - 1934	" " " " " " "	6:35-7:20 p.m.	26.00	26.0	82.32	80.00
G. A. Pangga	27 - V - 1934	" " " " " " "	6:40-7:10 p.m.	26.64	28.5	79.62	74.66
S. M. Cendaña ...	25 - V - 1935	" " " " " " "	6:55-7:30 p.m.	29.54	27.25	74.62	85.33
		Average		27.8 ± 0.4519	27.69 ± 0.1129	75.99 ± 1.7065	77.33 ± 1.8414

TABLE 3 (Continued)

NAME OF COLLECTOR	DATE	PLACE	TIME	SPECIES	NUMBER OF TERMITES COUNTED		SEX-RATIO
					Male	Female	
L. B. Uichanco ...	29 - VI - 1932	Los Baños, P. I.; Elev. 85 m.	4:45 a.m.	Macrotermes gilvus	85	10	0.1052
A. Y. Coronel	21 - VII - 1933	" " " " " 50 m.	4:50 a.m.	" "	624	296	0.3217
G. A. Pangga	26 - VII - 1933	" " " " " " "	7:25 p.m.	" "	180	176	0.4943
J. Pandialan	26 - VII - 1933	" " " " " " "	8:10 p.m.	" "	52	68	0.5667
G. A. Pangga	3 - VIII - 1933	" " " " " " "	7:15 p.m.	" "	441	367	0.4542
E. B. Ramos	3 - VIII - 1933	" " " " " " "	8:30 p.m.	" "	2,186	2,639	0.5469
F. N. Salcedo	11 - VIII - 1933	" " " " " " "	8:00 p.m.	" "	175	104	0.3728
G. A. Pangga	9 - V - 1934	" " " " " " "	7:20 p.m.	" "	82	73	0.4709
G. A. Pangga	6 - VI - 1934	" " " " " " "	7:30 p.m.	" "	735	356	0.3263
G. A. Pangga	10 - VI - 1934	" " " " " " "	7:40 p.m.	" "	65	58	0.4715
A. P. Cacayan	17 - IX - 1934	" " " " " " "	7:45 p.m.	" "	227	220	0.4922
G. A. Pangga	25 - V - 1935	" " " " " " "	6:55-7:30 p.m.	" "	102	86	0.4574
G. A. Pangga	18 - VI - 1935	" " " " " " "	7:35-8:30 p.m.	" "	1,658	732	0.3063
G. A. Pangga	19 - VI - 1935	" " " " " " "	7:30 p.m.	" "	798	733	0.4788
G. A. Pangga	12 - VII - 1935	" " " " " " "	7:00 p.m.	" "	110	65	0.3714
G. A. Pangga	16 - VII - 1935	" " " " " " "	7:15 p.m.	" "	142	86	0.3772
		Average		——	478.86	379.31	0.4133 ± 0.0445
G. A. Pangga	9 - V - 1934	Los Baños, P. I.; Elev. 50 m.	7:20 p.m.	Cryptotermes spp.	176	119	0.4034
G. A. Pangga	21 - V - 1934	" " " " " " "	6:35-7:20 p.m.	" "	77	57	0.4254
G. A. Pangga	27 - V - 1934	" " " " " " "	6:40-7:10 p.m.	" "	2,501	2,058	0.4514
S. M. Cendaña ...	25 - V - 1935	" " " " " " "	6:55-7:30 p.m.	" "	108	73	0.4033
		Average		——	715.5	576.75	0.4209 ± 0.0077

TABLE 4

Measurement of galleries of Cryptotermes nocens and Cryptotermes cynocephalus and counts of soldier and nymphs

WOOD NUMBER	COMMON NAME OF WOOD	SCIENTIFIC NAME OF WOOD [a]	DIMENSIONS OF WOOD PIECES			Length			
			Length	Width	Thickness	No. of tunnels measured	Min.	Max	Average
			cm.	*cm.*	*cm.*		*cm.*	*cm.*	*cm.*
1	Apitong	Dipterocarpus sp.	86.5	14.0	2.0	100	3.5	8.5	5.8 ± 0.3305
2	Palosapis	Anisoptera thurifera Blume	285.8	14.0	2.0	100	2.6	8.8	6.4 ± 0.3709
3	Apitong	Dipterocarpus sp.	154.2	14.0	13.0	100	4.3	8.9	5.8 ± 0.3777
4	,, ...	,, ,, ...	176.6	16.0	5.0	100	3.6	10.2	6.35 ± 0.3979
5	,, ...	,, ,, ...	145.2	14.5	2.2	100	3.8	8.3	6.25 ± 0.3102
6	,, ...	,, ,, ...	162.4	14.0	2.0	100	3.7	9.2	6.03 ± 0.3642
7	,, ...	,, ,, ...	115.6	8.0	3.6	100	3.8	7.7	6.23 ± 0.2428
8	,, ...	,, ,, ...	188.7	13.6	2.0	100	3.0	11.5	5.7 ± 0.5193
9	,, ...	,, ,, ...	262.4	7.6	5.2	100	2.8	9.2	6.56 ± 0.4047
10	,, ...	,, ,, ...	312.4	70.0	5.6	100	3.3	7.5	5.42 ± 0.3035

WOOD NUMBER	COMMON NAME OF WOOD	SCIENTIFIC NAME OF WOOD [a]	MEASUREMENT OF TERMITE GALLERIES					
			Width			Thickness		
			Min.	Max.	Average	Min.	Max.	Average
			cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
1	Apitong	Dipterocarpus sp.	0.3	1.6	0.93 ± 0.1097	0.4	0.8	0.53 ± 0.0472
2	Palosapis	Anisoptera thurifera Blume	0.5	1.0	0.66 ± 0.0269	0.3	0.7	0.5 ± 0.0202
3	Apitong	Dipterocarpus sp.	0.5	1.3	0.78 ± 0.0741	0.3	0.8	0.54 ± 0.0269
4	,, ...	,, ,, ...	0.6	1.2	0.91 ± 0.0404	0.4	0.6	0.5 ± 0.0405
5	,, ...	,, ,, ...	0.4	1.0	0.76 ± 0.0405	0.3	0.5	0.43 ± 0.0134
6	,, ...	,, ,, ...	0.5	0.9	0.66 ± 0.0917	0.4	0.6	0.49 ± 0.0168
7	,, ...	,, ,, ...	0.4	0.8	0.72 ± 0.0404	0.4	0.6	0.58 ± 0.0134
8	,, ...	,, ,, ...	0.4	0.8	0.77 ± 0.0067	0.3	0.7	0.51 ± 0.0256
9	,, ...	,, ,, ...	0.5	0.9	0.74 ± 0.0269	0.4	0.7	0.59 ± 0.0134
10	,, ...	,, ,, ...	0.4	0.8	0.58 ± 0.0276	0.3	0.5	0.41 ± 0.0155

[a] Determined by Mr. Ricardo Buhay.

TABLE 4 (Continued)

WOOD NUMBER	COMMON NAME OF WOOD	SCIENTIFIC NAME OF WOOD [a]	NUMBER OF TERMITES COUNTED		SOLDIER: NYMPH COEFFICIENT
			Soldier	Nymph	
1	Apitong	Dipterocarpus sp.	2	118	0.0169
2	Palosapis	Anisoptera thurifera Blume	7	1136	0.0062
3	Apitong	Dipterocarpus sp.	2	493	0.0041
4	”	” ”	11	1116	0.0099
5	”	” ”	5	374	0.0135
6	”	” ”	5	338	0.0149
7	”	” ”	10	386	0.0263
8	”	” ”	10	720	0.0139
9	”	” ”	12	1534	0.0079
10	”	” ”	18	1868	0.0097
			8.2	808.3	0.0123 ± 0.0013

TABLE 5

Effect of Paris green dust on dry-wood termites

WOOD NUMBER	COMMON NAME OF WOOD	SCIENTIFIC NAME OF WOOD [a]	MEASUREMENTS OF WOOD				TREATMENT	LAST INSPECTION	INTERVAL BETWEEN TREATMENT AND INSPECTION	AMOUNT OF ARSENIC USED		REMARKS
			Length	Width	Thickness	Volume				Total	Per cu. cm.	
			cm.	*cm.*	*cm.*	*cu. cm.*	*date*	*date*	*days*	*gm.*	*gm.*	
1	Palosapis	Anisoptera thurifera Blume	84.5	13.5	2.0	2,281.5	30 - V - 1935	23 - VI - 1935	24	1.8	0.00079	All termites killed.
2	Apitong	Dipterocarpus sp.	165.5	13.5	2.5	5,585.63	”	”	24	3.6	0.00064	” ” ”
3	”	” ”	181.0	14.0	2.0	5,068.00	”	”	24	4.4	0.00087	” ” ”
4	”	” ”	152.0	9.5	6.5	9,386.00	”	”	24	2.8	0.00029	125 termities living; the rest dead.
5	”	” ”	75.0	14.5	4.5	4,893.75	”	”	24	1.2	0.00025	All termites killed.
6	”	” ”	151.0	14.0	2.3	4,862.2	”	”	24	3.0	0.00062	” ” ”
7	”	” ”	191.0	9.0	5.0	8,595.0	”	”	24	3.6	0.00042	” ” ”
8	”	” ”	253.3	14.0	2.0	7,094.2	”	”	24	—	—	Check (no treatment): living termites.
9	Narig	Vatica sp.	111.0	14.0	2.0	3,108.0	”	24 - VI - 1935	25	2.1	0.00068	All termites killed.
10	”	” ”	157.0	15.0	5.5	12,952.5	”	”	25	3.5	0.00027	” ” ”
11	”	” ”	148.3	15.0	5.0	11,122.5	”	”	25	2.7	0.00024	” ” ”
12	”	” ”	239.0	14.0	2.0	6,692.0	”	”	25	5.2	0.00078	” ” ”

[a] Determined by Mr. Ricardo Bułay.

TABLE 6

Treatment of termitaria or tunnels of four species of subterranean termites with Paris green dust

NUMBER OF TREATMENT	SPECIES OF TERMITES	PART POISONED	AMOUNT OF PARIS GREEN	TREATMENT	FIRST INSPECTION	TIME INTERVAL FROM TREATMENT TO COMPLETE DISAPPEARANCE OR DEATH	REMARKS
			gm.	*date*	*date*	*days*	
1	Macrotermes gilvus	Tunnels on stump	0.8	4 - VI - 1935	4 - VI - 1935	2	All termites disappeared from the tunnel. Dead termite found down to 75 cm. below the ground.
2	” ”	” ” ”		”	”	2	Check (no treatment): living termites.
3	” ”	Mound	15.2	10 - VI - 1935	30 - VI - 1935	20	All termites killed in nest.
4	” ”	”		”	”	20	Check (no treatment): living termites.
5	” ”	Stump	0.7	25 - VI - 1935	28 - VI - 1935	3	Dead termites were found in the stump.
6	” ”	”	0.7	”	”	3	Dead termites were found in the stump.
7	” ”	”		”	”	3	Check (no treatment): living termites.
8	” ”	Tunnels on stump	0.4	3 - VIII - 1935	4 - VIII - 1935	1	All termites disappeared from the tunnel. No termite individual found down to 110 cm. below the ground.
9	” ”	” ” ”	0.4	”	”	1	All termites disappeared from the tunnel. No termite individual found down to 110 cm. below the ground.
10	” ”	” ” ”		”	”	1	Check (no treatment): living termites.
11	” ”	Tunnels on living trees	1.5	18 - VIII - 1935	19 - VIII - 1935	1	All termites disappeared. Not reinfested.

[a] Examination was made daily until the occupants in the treated lots have either been killed or disappeared.

TABLE 6 (Continued)

NUMBER OF TREATMENT	SPECIES OF TERMITES	PART POISONED	AMOUNT OF PARIS GREEN	TREATMENT	FIRST INSPECTION	TIME INTERVAL FROM TREATMENT TO COMPLETE DISAPPEARANCE OR DEATH	REMARKS
			gm.	*date*	*date*	*days*	
12	Macrotermes gilvus	Tunnels on living trees	1.5	”	”	1	All termites disappeared. Not reinfested.
13	” ”	” ” ” ”	1.5	”	”	1	All termites disappeared. Not reinfested.
14	” ”	Stump	1.5	”	”	1	All termites disappeared. Not reinfested.
15	” ”	”		”	”	1	Check (no treatment): living termites.
1	Microcerotermes los-bañosensis ..	Tunnels on living trees	0.3	6 - VI - 1935	8 - VI - 1935	2	2 dead termites found, the rest disappeared. No termite individual found down 95 cm. below the ground.
2	” ”	” ” ” ”		”	”	2	Check (no treatment); living termites.
3	” ”	Stump	1.8	11 - VIII - 1935	14 - VIII - 1935	3	All termites killed in stump.
4	” ”	”	1.8	”	”	3	All termites killed in stump.
5	” ”	”		”	”	3	Check (no treatment): living termites.
6	” ”	Nest	9.6	24 - VIII - 1935	15 - IX - 1935	22	All termites killed in nest.
7	” ”	”		”	”	22	Check (no treatment): living termites.
8	” ”	”	7.6	31 - VIII - 1935	18 - IX - 1935	18	All dead.
1	Nasutitermes luzonicus ...	Tunnels on living trees	0.9	17 - VI - 1935	24 - VI - 1935	7	All termites disappeared from the tunnel. No termite individual found below the ground.
2	” ” ...	” ” ” ”	0.9	”	”	7	All termites disappeared from the tunnel. No termite individual found below the ground.

TABLE 6 (Continued)

NUMBER OF TREATMENT	SPECIES OF TERMITES	PART POISONED	AMOUNT OF PARIS GREEN	TREATMENT	FIRST INSPECTION	TIME INTERVAL FROM TREATMENT TO COMPLETE DISAPPEARANCE OR DEATH	REMARKS
			gm.	*date*	*date*	*days*	
3	Nasutitermes luzonicus ...	Tunnels on living trees	0.9	”	”	7	All termites disappeared from the tunnel. No termite individual found below the ground.
4	” ” ...	” ” ” ”		17 - VI - 1935	”	7	Check (no treatment): living termites.
5	” ” ...	Nest	5.3	27 - X - 1935	10 - XI - 1935	14	All termites killed in nest.
6	” ” ...	”		”	”	14	Check (no treatment): living termites.
7	” ” ...	Tunnels in dead wood	0.6	1 - XII - 1935	4 - XII - 1935	3	Dead termites found inside the wood.
8	” ” ...	Nest	12.6	19 - I - 1936	3 - II - 1936	15	All termites killed in nest.
9	” ” ...	”	12.6	”	8 - II - 1936	20	All termites killed in nest.
10	” ” ...	”		”	”	20	Check (no treatment): living termites.
1	Coptotermes vastator	Petroleum box	1.3	16 - XII - 1934	17 - XII - 1934	1	All termites disappeared. Not reinfested.
2	” ”	Wooden post	2.3	22 - I - 1935	23 - I - 1935	1	All termites disappeared. No termite individual found down 1.5 meters below the ground.
3	” ”	Bamboo	3.5	2 - III - 1935	3 - III - 1935	1	All termites disappeared. Not reinfested.
4	” ”	Tunnel on wooden post	0.6	17 - VII - 1935	18 - VII - 1935	1	All termites disappeared. Not reinfested.
5	” ”	Pamphlets	0.8	8 - IX - 1935	9 - IX - 1935	1	285 termites were left killed on a cement floor and the rest disappeared.

TABLE 7

College buildings inspected for termites infestation and treated with Paris green

NAME OF BUILDING	SPECIES OF TERMITES FOUND	PART OF THE BUILDING INFESTED	TREATMENT	LAST INSPECTION	INTERVALS BETWEEN TREATMENT AND LAST INSPECTIÓN	REMARKS
			date	*date*	*days*	
Animal Husbandry	Macrotermes gilvus	Door jamb	12 - XI - 1935	23 - XI - 1935	11	All termites disappeared in the tunnel.
	Microcerotermes los-bañosensis	" "	"	"	11	
Agricultural Chemistry	Macrotermes gilvus	" "	23 - XI - 1935	2 - XII - 1935	9	All termites disappeared in the tunnel.
Agricultural Engineering	Cryptotermes spp.	Portion of door frame	23 - XI - 1935	21 - XII - 1935	28	[a]
Entomology	Macrotermes gilvus	Door jamb	9 - IX - 1935	10 - IX - 1935	1	All termites disappeared in the tunnel.
	Coptotermes vastator	Portion of door frame	16 - IX - 1935	19 - IX - 1935	3	All termites disappeared in the tunnel.
Economics	Macrotermes gilvus	Floor, partition walls	7 - IX - 1935	21 - XI - 1935	14	All termites disappeared in the tunnel.
	Microcerotermes los-bañosensis	Joist, beam	"	"	14	All termites disappeared in the tunnel.
	Cryptotermes spp.	Beam	"	"	14	[a]
Limnological Station	Cryptotermes spp.	Floor and studs	28 - XII - 1935	2 - II - 1936	36	[a]

[a] The infested woods have not been dissected as they have not been removed from the building. Basing upon the absence of the fecal pellets, however, the termites seemed to be under control.

EFFECTS UPON YOUNG SUGAR CANE PLANTS OF VARYING THE MOISTURE CONTENT OF CLAY LOAM SOIL IN POTS[1]

BARTOLOME P. JAVIER

WITH THREE TEXT FIGURES

Although sugar cane is an important crop in this country there is no record of any study on the effects of varying moisture content of soil on this plant when grown in the Philippines. It would seem to be desirable to determine the water needs of sugar cane plants, and to find out how far the amount of water in the soil will influence the yield of canes and of sugar.

In the work on this subject reported in this paper it was not possible to carry out the experimental work to the full maturity of the plant, because of the small size of the pots (20 liter kerosene cans) available.

The experiment, however, was considered as finished, though the plants were not mature, as it is an accepted fact that the condition of the initial growth and development of a plant, especially the sugar cane, largely determines its later life.

REVIEW OF LITERATURE

No Philippine literature on the water relation of the sugar cane was on record. For the purpose, however, of comparison with the results obtained from the present study, studies made in other countries are included in this review.

Arnold (1924) presents results of his own studies and cites those of Agee and of Maxwell. He divides the growth of the sugar cane plants in British Guiana into four periods; namely, (*a*) early growth, (*b*) growth up to three months, (*c*) vigorous growing period, and (*d*) ripening period. On results of his studies, Arnold recommends for early growth of the cane plants a little irrigation at the rate of one to two inches at intervals of seven days; for the vigorous growing period, he recommends three inches a week; for the ripening period of the plant, a less amount of irrigation water, gradually reducing until the time of harvest.

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[1] Thesis presented for graduation from the College of Agriculture, Los Baños, 1934 with the degree of Bachelor of Science in Agriculture, No. 501; Experiment Station contribution No. 1128. Prepared in the Department of Plant Physiology under the direction of Dr. Rafael B. Espino.

Arnold cites Agee's findings in Hawaii to the effect that on an average, a million gallons of water are consumed to produce one ton of sugar, an amount, according to Arnold, equivalent to 33 inches per acre, or 99 inches to give three tons per acre. He further cites results of Maxwell's studies to the effect that sugar cane plants seventeen months old had consumed 27.01 inches of water from the rain and 76.6 inches from irrigation water, or a total of 103.51 inches of water.

Eckart's study, as cited by Deerr (1921), obtained results under Hawaiian conditions showing that 31.38 per cent of water in soil was best to promote growth and development of sugar cane plants. A similar study, also under Hawaiian conditions, was made by Alexander (quoted by Krisknomurthi, 1929). Alexander found that 26 per cent soil moisture was good for the growth of sugar cane plants. He also found that when the moisture content of the soil fell below 20 per cent, the sugar cane plants wilted. According to Krisknomurthi about 70 to 140 inches of water are required by the plants for good growth.

It has also been reported that cane plants grown in coral soils require the largest amount of water. Cane plants as old as 24.8 months need 15.72 acre-feet of water. In adobe soil, cane 23 months old requires 9.92 acre-feet of water and on good soil, cane 24.1 months old requires 12.81 acre-feet. The average plant cane 24.1 months old requires 12.81 acre-feet of water. In coral soil, the old long ratoon cane 20.8 months old requires 13.32 acre-feet; in adobe, cane 20 months old requires 9.17 acre-feet; in good soil, cane 20.8 months old requires 10.00 acre-feet of water. The average long ratoon 20.6 months old grown in different soils requires 11.04 acre-feet. The short ratoon cane 18.5 months old, in coral soil, requires 11.06 acre-feet; in adobe, 19 months old, 9.08; in good soil, 18 months, 9.82. The average short ratoon, 18.4 months old, in good soil requires 10.19 acre-feet of water.

The work on the water requirements of other plants are not here reviewed but will be referred to under discussion of results of the present study. The works of Palis (1935), Briggs and Shantz (1913), Harris (1914), Harris and Maugham (1917) and of Harris and Pittman (1917) are of interest.

OBJECT, TIME AND PLACE OF STUDY

The object of the present study was to determine the effects upon growth and development of young sugar cane plants of varying the moisture contents of clay loam soil in pots.

This study which consisted of different sets of cultures was conducted near the laboratory of the Department of Plant Physiology of the College of Agriculture at Los Baños. It was begun on January 30, 1932 and ended on February 17, 1933, covering a period of about twelve and a half months.

MATERIALS, METHODS AND RESULTS

The variety used

The variety of sugar cane used in this study was Luzon White. Ordinary seed pieces, or cuttings were secured from the Department of Agronomy. Cuttings of about the same size and age were selected and cut into smaller pieces so that each had only one "eye", or bud. These small cuttings were soaked in water for about 24 hours, and germinated in a seed box filled with sterilized sand. Buds soon began to sprout and when the shoots were long enough to handle, young plants apparently of about the same size and state of development were selected and transplanted to the pots which contained equal amounts of clay loam soil; one plant to a pot.

The culture media

Kerosene cans were used as culture pots. In the top of each can an opening about 10 centimeters square was cut out with a pair of shears. Then the cans were thoroughly washed with water and soap.

Clay loam soil gathered from the experimental plots of the Department of Plant Physiology was used as the solid medium. The soil was collected and piled on a concrete floor where it was cleaned, pulverized and sieved. Then, the soil was thoroughly mixed and spread on the floor under shelter to dry. When sufficiently air-dry, the moisture content of two samples of the soil was determined by the usual method. The data obtained from this determination were used in computing the total moisture content of the soil in the different pots. This procedure was followed in the three sets of cultures tried. In each set, thirty of the kerosene can "pots" were each filled with 18 kilograms of the air-dry soil. To aid in getting a uniform distribution of water in the soil in the pots, two small bamboo tubes about 30 centimeters long, open at the upper end and closed at the bottom end, and with small holes made along the sides, were pushed into the soil in each pot with the open ends of the tubes just at the surface.

The different degrees of moisture saturation of soil in pots were next determined. Pot X was saturated with water,[2] but not over-saturated. This saturation was taken arbitrarily as 100 per cent saturation. The amount of water originally present in the soil and the amount of water actually added were added together. The sum constituted the total amount of water in the 100 per cent saturation. Pot IX had 90 per cent saturation, obtained by adding to the soil in this pot 90 per cent of the amount of water contained in the 100 per cent saturation minus the original moisture in the soil. By following this method of computation, the 80, 70, 60, 50, 30, 20, and 10 per cent saturations were prepared.

When the pots were thus prepared, they were planted with sugar cane seedlings previously germinated, one plant to each pot. To prevent rapid evaporation of water from the soil in pots, each opening was covered with pieces of tin.

Method of watering the plants

One week after planting and at the end of every week thereafter two soil samples were taken from each culture with a soil auger driven to the bottom of the pots. These samples were placed in crucibles, dried to constant weight in a Freas' electric oven and the percentages of moisture, determined. The data obtained were used in computing the amount of water that was lost from each pot during the week. Then, an equivalent amount of water was poured into the pot through the bamboo tubes.

Care of the cultures

In the day time the cultures were placed out doors in the sun. To protect them from rain they were placed (one set at a time) on a long table fitted with rollers and thus were easily moved under shelter. They were placed under shelter in the late afternoon.

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[2] Water was gradually poured on the soil in the pot. When standing water came to the surface, then percentage of saturation was arbitrarily considered 100 per cent.

The experimental work

The first set of cultures was started on January 30, 1932 and consisted of ten duplicate cultures. The original moisture content of the soil in the different cultures was made up by adding water at the end of every week. On May 2, 1932, or 99 days after planting, the cultures were photographed (fig. 1), and subsequently harvested. The experimental data obtained under the different criteria of results used are recorded in tables 1 to 11.

The second set of cultures was started on June 15, 1932 and consisted of ten triplicate cultures. As in the first set of cultures, the moisture content of the soil in the different cultures was made up by adding water at the end of every week. This set was a repetition of the first set of cultures and on September 15, 1932 or 151 days after planting, the plants were photographed (fig. 2) and then harvested. The data obtained under the different criteria of results employed are given in tables 1 to 11.

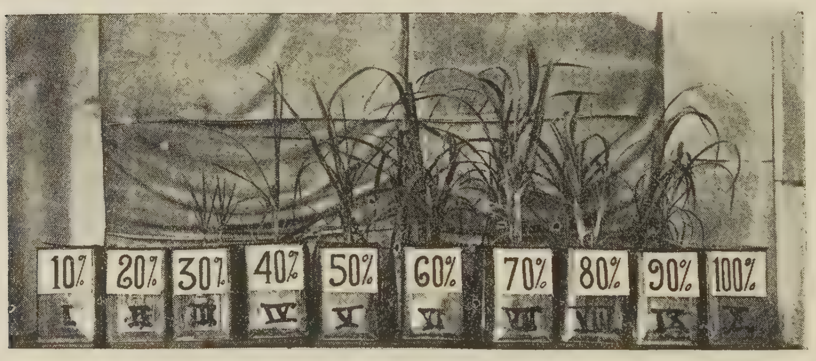

Fig. 1.—Sugar cane plants at the time of harvest. Labels on pots show culture numbers and per cent of saturation. Numerical data are in tables 1-11. Plants grown in pots from January 30 to May 8, 1932.

The third set of cultures was started on November 3, 1932 and consisted of ten triplicate cultures. This set was a repetition of the sets of cultures previously harvested. On February 17, 1933, or when the plants were 106 days old the cultures were photographed (fig. 3). Then, the plants were harvested. The experimental data obtained under the different criteria of results employed are recorded also in tables 1 to 11.

DISCUSSION OF RESULTS [3]

Introductory remarks

The best criteria of results for experiments on the water relation of the sugar cane plant are the tonnage of canes produced and the yield of sugar. These criteria, however, were not employed in this study because the pots used were not large enough to allow the plants to reach maturity. The plants were harvested at the age of five months or less.

Nevertheless, the results obtained from the three sets of cultures should be of value, especially from the standpoint of physiology, because it is a well known fact that the latter part of the life of a plant is materially influenced by its earlier life; a healthy vigorous plant usually develops into a healthy and well-developed mature plant. For this reason, and because the plants were harvested when five months old, it was deemed advisable to reckon the comparative merits of the different cultures in term of a number of criteria; namely, (*a*) *number of suckers and of leaves, height of plants, length of visible stem, and of roots, and diameter of stem,* (*b*) *fresh weight of shoot,* (*c*) *weight of dry roots,* (*d*) *weight of sun-dried shoot,* and (*e*) *dry weight of plants.* Incidentally, data were also gathered for the determination of the "water requirement with evaporation" of the young sugar cane plants produced from the different culture media tested.

Because of the failure to bring the plants to complete maturity, it is not imperative that the data on hand be studied in their actual or absolute values. Hence, the data obtained from this study are here considered only relatively.

Comparative merits of the cultures as judged from the illustrations

The photographs (fig. 1, 2, and 3) taken at the time of harvest show that the cultures supplied with 10, 20, and 100 per cent saturation had no plants. The young sugar cane plants that were planted in these cultures did not continue to grow. They soon died. The rest of the cultures in each set—those supplied with 30, 40, 50, 60, 70, 80, and 90 per cent saturation—had plants in different states of development at the time of harvest. Judged by the external appearance of the plants cultures VI and VII were about the best in the set. These were the cultures supplied with 60 and 70 per cent saturation. Which of the two was the better is shown by numerical data in tables 1 to 10, or more specifically in tables 6, 8, 9 and 10 shown in this report. Of course, the cultures that were supplied with 50 or 80 per cent saturation were not poor.

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[3] Tables 1–5 and tables 7 and 11 are on file in the Department of Plant Physiology, College of Agriculture.

Comparative study of the data

Tables 1 to 10 show that no numerical data are given under the different criteria of results employed for cultures I, II, and X. The reason was that the plants that were grown in these cultures did not continue to grow and consequently were not harvested. Cultures I, II, and X were supplied with 10, 20, and 100 per cent saturation, respectively. It appears that in the first two cultures, the plants died owing to lack of water in the soil, whereas, the death of the plants in culture X was probably due to the presence of too much water in the soil, a condition known to produce poor aëration of the soil.

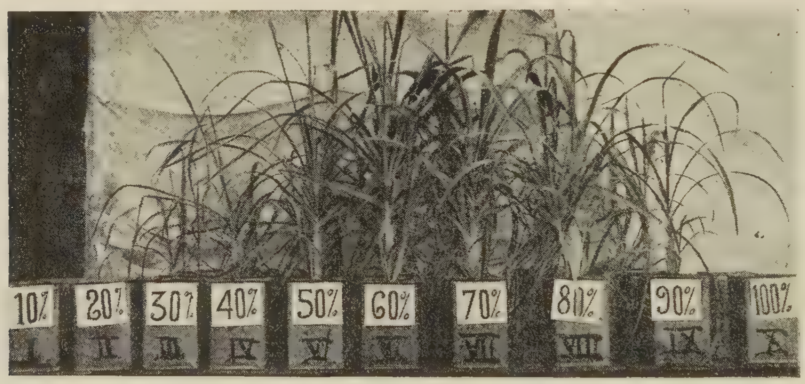

Fig. 2.—Sugar cane plants at the time of harvest. Labels on pots show culture numbers and per cent of saturation. Numerical data are in tables 1-11. Plants grown in pots from June 15 to November 13, 1932.

Number of suckers and of leaves, height of plants, length of stem and of roots, and diameter of stem. As shown in tables 1 to 10, among the cultures that grew sugar cane plants, no suckers were produced in culture III which contained 30 per cent saturation. Some of the plants in cultures IV, V, VIII and IX failed also to produce suckers. However, all of the plants in cultures VI and VII produced suckers, a fact which seems to indicate that 60 and 70 per cent saturation were the best from the standpoint of sucker production. It is likewise shown that the cultures that had 60 and 70 per cent saturation produced the largest number of leaves on the young sugar cane plants. However, the culture that had 80 per cent saturation was also fairly good in this respect. In term of height of the plant, cultures VI and VII may also be considered, on the whole, as the best in the lot. In length of visible stem, these two cultures were also the best, although the cultures that were supplied with 50, 80 and 90 per cent saturation also produced relatively long stems. Relatively long roots were also produced by the plants supplied with 60 and 70 per cent saturation. It is, further shown that cultures VI and VII again were found to be the two best in VIII, which received 80 per cent saturation, may be considered as fair. The rest of the cultures were poor, either the plants grown therein soon died, as in cultures I, II and X, or the data on diameter of stems were relatively low, as in cultures III, IV, V and IX. Thus, it may be safely concluded that 60 and 70 per cent saturation were the most favorable for the young sugar cane plant in production of suckers and leaves, and height of plants, length of stem and of roots, and diameter of stem.

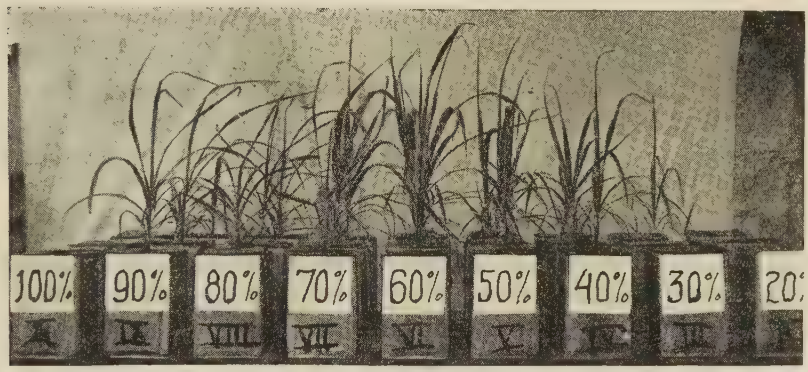

Fig. 3.—Sugar cane plants at the time of harvest. Labels on pots show culture numbers and per cent of saturation. Numerical data are in tables 1-11. Plants grown in pots from November 3, 1932 to February 17, 1933.

Effects on weight of fresh shoots. When the two highest values under each vertical column in table 6 were arbitrarily selected and indicated by H, it was found that most of the H's fell under cultures VI and VII, and as in the previous cases some under culture VIII. This fact, again, seems to indicate that the two best cultures in the lot under the criterion of fresh weight of top were those supplied with 60 and 70 per cent saturations and that the culture supplied with 80 per cent saturation was not a very poor culture, if judged under this criterion.

Effects on weight of dry roots. When again the arbitrary selection of the two best cultures in the lot was made in term of weight of dry roots, table 8 shows that cultures VI and VII were the best, as most of the H's fall under these cultures. Of these two cultures, culture VI was by far the better. Therefore, in production of roots 60 per cent saturation was the best and 70 per cent saturation was the next best.

Effects on weight of dry tops. By the arbitrary method of selection used in this study, the two best cultures shown in table 9 were found to be cultures VI and VII, as most of the H's fall under these two. Therefore, in promoting the development of tops of young sugar cane plants 60 and 70 per cent saturations were the best. A relatively few H's fall under culture VIII, in which the plants were supplied 80 per cent saturation. This culture was fair when yield of top was concerned.

Effects on weight of dry plants. The two best cultures, by the arbitrary method of selection here followed, were again VI and VII. These two cultures received the two largest number of H's. Of course, as shown in table 10, culture VI was the better culture of the two not only that it received the maximum possible number of H's but also that, except in two cultures out of the total of eight, its *actual values* were higher than the corresponding *actual values* produced from culture VII. Hence, under the criterion of dry weight of plants, 60 per cent saturation was the best in the lot, and 70 per cent saturation was the next best. As in previous cases, 80 per cent saturation produced relatively high data on dry weight of the plant.

Critical determination of relative merits of cultures

To be able to determine more critically the relative merits of the cultures tested, the data under the different criteria of results employed were again studied. These data are in tables 1 to 10, inclusive. The *actual values* under each criterion of results were added together. This computation was made for all the cultures in which young sugar cane plants reached the time of harvest, and the results, in term of *relative values* are shown in the following tabulation:

CULTURE NO.	WATER SATURATION	TOTAL YIELD DATA IN RELATIVE VALUE [a]									
		Number of suckers	Number of leaves	Height of plants	Length of visible stems	Diameter of stems	Fresh weight of shoots	Length of roots	Weight of dry roots	Weight of sun-dried top	Dry weight of plants
	per cent										
I	10										
II	20										
III	30		24	17	7	21	7	40	8	7	7
IV	40	28	35	29	16	38	18	72	20	18	18
V	50	46	63	60	48	61	52	92	47	51	50
VI	60	100 (43)	100 (275)	100 (673.8) cm.	100 (102.9) cm.	100 (21.9) cm.	92	100 (532.5) cm.	100 (108.4) grams	100 (464.0) grams	100 (572.0) grams
VII	70	72	88	87	99	92	100 (1731.1) grams	96	90	94	93
VIII	80	33	67	71	80	57	85	84	87	73	76
IX	90	46	58	68	48	61	43	75	47	43	45
X	100										

[a] The highest *actual value* under each criterion was arbitrarily considered 100; the rest of the *actual values* under the same criterion were computed to the assumed highest relative or arbitrary value.

Examination of the data in the preceding tabulation shows that culture VI in which the young sugar cane plants were supplied with 60 per cent saturation was the best among the cultures tested. To support this conclusion the *relative values* of 100 fall in culture VI under nine out of the total ten criteria of results employed, and the one *relative value* below 100 was sufficiently high, being 92. The next best culture was culture VII which was supplied with 70 per cent saturation. High *relative values* fall in this culture under all the criteria of results employed. In fact, one *relative value* of 100 and six of 90 and above are in this culture. The remaining *relative values* under this culture were relatively high, being 88.87, and 72. The third best culture was culture VIII, because most of the *relative values* shown are comparatively high, being for the most part above 70 and some were above 80. This culture had 80 per cent saturation. The rest of the cultures, that is, those supplied with 30, 40, 50, and 90 per cent saturation, may be considered as unsatisfactory for the young sugar cane plants, as judged according to the ten criteria of results used.

Data of "water requirements with evaporation" of young sugar cane plants

Table 11[4] showed the data on "water requirements with evaporation" of the young sugar cane plants. By this term is meant the amount of water (in grams) that was needed to produce the dry weight of the plant. Inasmuch as no special care was taken to prevent evaporation of water from the pot, the term *with evaporation* as used by Briggs and Shantz (1913) is employed here. The sum total of the amount of water that was lost from each culture from time to time as determined by the weekly renewal of the original moisture content of the soil was used in this study in the determination of the data on water requirements. As the culture pots had no drainage holes in the bottom and the sides, being tin, were impervious to water, the loss of water from the pot was due mainly to transpiration of the plants and to evaporation of water through the small mouth of the pot which was covered partly with pieces of tin.

After making the necessary computation, that is, after dividing the total amount of water lost (in grams) from each culture by the dry[5] weight (also in grams) of the young plant produced by that culture, it may be seen from the results recorded in table 11, that from the same culture the data thus obtained from the several replications of culture are not uniform. This lack of uniformity shows the variability in *water requirement* of the individual plants as the experiments were conducted at different times. This variability, which was observed also by Palis (1935) on rice, presents difficulties in drawing conclusions. For this reason, it was deemed wise to make no further study of the data on hand.

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[4] On file in the Department of Plant Physiology.

[5] No doubt there must still be a little water in the "sun-dried" top, but since evaporation of water from the pots was not completely checked, the "sun-dried" tops will serve the purpose of the computation.

Compiling results of water relation experiments

In reading the literature, herein cited, on the water relation of plants, especially of the sugar cane plant, attention was attracted by the various *units of measure* of water supply employed. Agee (see Arnold, 1924) of Hawaii employed *gallons* of water; Maxwell and Krisknomurthi both used *inches* of water; Arnold used *inches per week;* Eckart, Alexander, and Harris employed *per cent* of water in soil; Renton and Alexander used *acre feet* of water; Briggs and Shantz, and Fortier employed *water requirement,* and *water requirement with evaporation;* and Palis, and in the present study, *per cent saturation* of the soil was used.

These various units reveal the difficulties encountered when data from water relation or water requirement experiments were compared. For this reason, it was deemed sufficient in this report to cite or compile data on the subject, and to point out the merits of the unit *per cent saturation* of soil employed in the present study and to recommend general adoption of this unit, at least, in pot culture studies on water relation of plants.

From the available literature on water relation, the following data were noted. Agee (see Arnold, 1924) found that on the average, a milion gallons of water were consumed to produce one ton of sugar in Hawaii. Maxwell (cited by Arnold, 1924) reported that sugar cane plants seventeen months old consumed 103.51 inches of water. But, Krisknomurthi (1929) contends that about 70 to 140 inches are needed by the plant. Eckart (see Deerr, 1921) found that under Hawaii conditions 31.38 per cent of water in soil was the best amount for promoting growth and development of sugar cane plants. Alexander (cited by Krisknomurthi, 1929) reported 26 per cent soil moisture as good for this plant; that 20 per cent caused wilting. In the present study, it was found that 20 per cent saturation or less soon killed young sugar cane plants, and that 60, 70 and 80 per cent saturations were found to be fairly good.

Available literature on experiments with other plants shows that Harris and Pittman (1917) found that in plot cultures, 20 inches of water gave the highest yield of grain of corn, and 30 inches of water produced the highest yield of stover. With wheat, Harris (1914) found that 37.5 per cent moisture of clay loam soil in pots produced the maximum yield of both grain and of straw. He also found that a moisture content of the soil of about 37.5 per cent produced a decrease in yield. Good yield of wheat was obtained by Harris and Maugham (1917) from pots containing moderate amounts of moisture, but the yields on the wet and very dry soil were decidedly low. In the water saturated cultures, the plants failed to produce grain.

With rice, Palis (1935) obtained the best growth and development of rice plants 40 days old from cultures that had 80 per cent saturation in clay loam soil in pot. Water saturation of 70 per cent was also found to be good for the plant. But, 60 per cent saturation or less produced rather poorly developed plants. Palis also found that 90 and 80 per cent saturations were conducive to early ripening of grain. Young sugar cane plants appear to have different water requirements, because from the present study, 60 per cent saturation, also in clay loam soil, was the best for the plant; 70 per cent saturation was the next best. The water saturations in which the young and old rice plants were able to grow ranged from *supersaturated* to 30 per cent; while young sugar cane plants acquired a narrower range, being only from 90 to 30 per cent saturation. Water saturation of 100 and 20 and 10 per cent soon killed young sugar cane plants.

SUMMARY AND CONCLUSIONS

Under the conditions of this study, it appears that it is possible to draw the following generalizations:

1. The plants in cultures that had 10, 20, and 100 percent saturations failed to continue to grow. They soon died.

2. No sucker was produced from the 30 per cent saturation, and in the 40, 50, 80, and 90 per cent saturations some of the plants produced no suckers. None of the plants in cultures supplied with 60 and 70 per cent saturations failed to produce suckers; these two cultures were the best in the lot in this respect.

3. The cultures that had 60 and 70 per cent saturations were not only the highest producers of suckers, but also the two best cultures under all the criteria on number of leaves, height of plants,

length of stem and of roots, diameter of stem, fresh weight of shoot, weight of dry roots, weight of sun-dried shoot, and dry weight of whole plant. Of the two, the 60 per cent saturation was the better for the young sugar cane plant. However, the 80 per cent saturation also produced fairly good results under the criteria of results used.

4. The cultures that had 30, 40, 50, and 90 per cent saturations may be considered as unsatisfactory for the young sugar cane plants.

5. Owing to divergence or variability of results obtained from "water requirements with evaporation" of the young sugar cane plant, it was not possible to draw conclusions.

6. Available data on water relation experiments with sugar cane, corn, wheat, and rice plants were compiled.

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TABLE 6

Showing effects of varying the moisture content of clay loam soil in pots on the weight of fresh tops of young sugar cane plants

CULTURE NO.	PERCENTAGE OF WATER SATURATION	WEIGHT OF FRESH TOPS,[a] IN GRAMS															
		In Experiment 1 (January 30 to May 8, 1932)				In Experiment 2 (June 15 to November 13, 1932)						In Experiment 3 (November 3, 1932 to February 17, 1933)					
		main shoot		suckers		From main shoot			From suckers			From main shoot			From suckers		
		a	b	a	b	a	b	c	a	b	c	a	b	c	a	b	c
I[b]	10																
II[b]	20																
III	30	9	9	0	0	33	37	13	0	0	0	1	10	1	0	0	0
IV	40	27	27	0	0	32	61	63	0[c]	0[c]	2	29	28	20	0	2	0
V	50	45	43	5	0	195	191	162	14	51H	58	28	47	53	1	0	7
VI	60	98H	86H	22H	49H	349	241H	314	45	57H	97H	53H	84H	79H	2H	7H	6
VII	70	113H	158H	13	42H	417H	286H	336H	157H	0[c]	45	56H	69H	46	2H	5H	8H
VIII	80	88	28	43H	0	381H	205	387H	97H	0[c]	100H	28	31	64H	1	0	14H
IX	90	28	23	9	32	135	156	154	0	0	7	50	61	21	1	2	5
X[b]	100																

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[a] *a* and *b* were duplicate cultures; *a*, *b*, and *c*, were triplicate cultures.

[b] The plants soon died.

[c] The suckers were very small, each weighing less than one-half gram.

TABLE 8

Showing effects of varying the moisture content of clay loam in pots on the weight of dry roots of young sugar cane plants

CULTURE NO.	PERCENTAGE OF WATER SATURATION	WEIGHT OF DRY ROOTS [a], IN GRAMS							
		In Experiment 1 (January 30 to May 8, 1932)		In Experiment 2 (June 15 to November 13, 1932)			In Experiment 3 (November 3, 1932 February 17, 1933)		
		a	b	a	b	c	a	b	c
I [b]	10								
II [b]	20								
III	30	0	1	2	3	2	0	1	0
IV	40	2	2	4	7	1	2	2	2
V	50	5	4	12	8	12	2	5H	4H
VI	60	13H	14H	23H	24H	18	6H	5H	6H
VII	70	14H	18H	21	12	20H	5H	4	3
VIII	80	12	3	29H	17H	27H	2	2	2
IX	90	2	6	11	13	12	4	7H	1
X [b]	100								

[a] *a* and *b* were duplicate cultures; *a*, *b*, and *c* were triplicate cultures.

[b] The plants soon died.

TABLE 9

Showing effects of varying the moisture content of clay loam soil in pots on the weight of sun-dried tops of young sugar cane plants

CULTURE N[a].	PERCENTAGE OF WATER SATURATION	WEIGHT OF DRY TOPS [a], IN GRAMS															
		In Experiment 1 (January 30 to May 3, 1932)				In Experiment 2 (June 15 to November 13, 1932)						In Experiment 3 (November 3, 1932 to February 17, 1933)					
		From main shoot		From suckers		From main shoot			From suckers			From main shoot			From suckers		
		a	b	a	b	a	b	c	a	b	c	a	b	c	a	b	c
I [b]	10																
II [b]	10																
III	30	2	2	0	0	9	11	4	0	0	0	0	4	0	0	0	0
IV	40	7	7	0	0	7	20	16	0 [c]	0 [c]	0	9	9	7	0	1	0
V	50	10	11	1	0	46	54	44	3	11H	13	8	18	16	0 [c]	—	3
VI	60	25H	22H	8H	10H	104H	90H	78H	10	12H	20H	25H	32H	22H	1H	2H	3H
VII	70	29H	40H	3	11H	111H	68H	78H	40H	0 [c]	9	11	21	13	0 [c]	1H	2
VIII	80	22	6	11H	0	73	54	76	25H	0 [c]	27H	8	9	19H	0 [c]	0	5H
IX	90	7	16	3	9	30	40	39	0	0	2	19H	22H	7	0	1	2
X [b]	100																

[a] *a* and *b* were duplicate cultures, *a*, *b*, and *c*, were triplicate cultures.

[b] The plants soon died.

[c] The suckers were too small, weighing less than one-half gram each.

TABLE 10

Showing effects of varying the moisture content of clay loam soil in pots on the weight of dry young sugar cane plants, tops and roots

CULTURE NO.	PERCENTAGE OF WATER SATURATION	DRY WEIGHT OF SHOOTS AND ROOTS[a], IN GRAMS							
		In Experiment 1 (January 30 to May 8. 1932)		In Experiment 2 (June 15 to November 13, 1932)			In Experiment 3 (November 3, 1932 February 17, 1933)		
		a	b	a	b	c	a	b	c
I[b]	10								
II[b]	20								
III	30	2	3	11	13	6	0[c]	5	0[c]
IV	40	10	9	12	27	17	11	11	9
V	50	14	15	60	73H	69	10	23	23H
VI	60	46H	46H	137H	127H	116H	32H	39H	31H
VII	70	43H	69H	171H	80H	108H	16H	26H	18
VIII	80	45H	9	127H	71	131H	11	11	26H
IX	90	15	30H	41	53	53	24H	35H	10
X[b]	100								

[a] *a* and *b* were duplicate cultures; *a*, *b*, and *c* were triplicate cultures.
[b] The plants soon died.
[c] Each sucker weighed less than one-half gram.

A STUDY OF VARIABILITY IN CLONAL PROGENY OF THE SWEET POTATO [1]

FABIAN O. SOLPICO

Wester (1924) compiled about 200 native variety names of which many are probably synonymous. This large number of varieties may be attributed in part to the variability produced within sweet-potato varieties. This plant is commonly propagated by vine cuttings, but some of its varieties will also reproduce sexually. This dual aspect of propagation gives rise to two methods of improvement. The first method consists of selection of desirable variations arising from the production of seedlings and the second, the selection and propagation of bud variations that may arise in a clonal population. The present investigation deals with the latter method of improvement and is concerned with a search for bud variations in some local sweet potato varieties propagated by different asexual means.

REVIEW OF LITERATURE

Not much work has been done on bud variability in sweet potato. In the Philippines, Mendiola (1921) reported the variability of plants from seeds of sweet potato and selected three types of seedling varieties, one for yield, the second, for flavor and the third, for fancy color.

Harter (1926) found one plant of the Haiti variety of sweet potato which produced three red roots and three yellow ones. He states that the Haiti strain had been propagated by sprouting of the roots, so the bud sports could not be the result of hybridization.

Rosa (1926) stated that sweet potatoes in the United States, with the exception of those grown in Florida, do not produce seeds, hence, the development of new forms lies in the search for and propagation of bud mutations. He observed the presence of a white-skinned root in the Red Bermuda variety and two white roots on a plant of the Yellow Jersey variety, one root longitudinally striped with white and yellow and several normal yellow.

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[1] Thesis presented for graduation, 1935, with the degree of Bachelor of Science in Agriculture from the College of Agriculture, No. 502; Experiment Station contribution, No. 1129. Prepared in the Department of Agronomy under the direction of Dr. José M. Capinpin.

Miller (1930) reports the occurrence in the Porto Rico variety of sweet potato of bud variations collected during harvest time. The mutations he found were: (*a*) White skin which was different from the normal Porto Rico variety. When planted, they proved true to type. (*b*) White flesh but the color and shape of the roots resembled the normal Porto Rico variety. (*c*) The most common mutation, white skin and white flesh the roots of which were longer, coarser and more oblong than the normal Porto Rico.

OBJECTS OF THE PRESENT WORK

The objects of this study were: (*a*) to make a comparative study of the variability in clonal progeny of sweet potato: (*b*) to discover the best means of obtaining variations through asexual propagation; and (*c*) to record any bud variations which might be obtained through asexual propagation.

TIME AND PLACE OF THE WORK

The experiments were conducted in the Plant Breeding Nurseries and in the Experiment Station fields of the Department of Agronomy, College of Agriculture, University of the Philippines, from November, 1933, to February, 1935.

MATERIALS

Varieties used

Four varieties of sweet potato were used. They are the common varieties in the market and differ in color of the skin and the flesh and in size of the roots. These varieties are: (1) Inube, with purple skin and purplish white flesh. (2) Minaynila, with yellow skin and yellow flesh, (3) Nilabanos, with white skin and white flesh, (4) Red variety, with red skin and white flesh. The Inube, Minaynila and Nilabanos were obtained from Nagcarlan, Laguna; the Red variety was secured from the stock of the Department of Agronomy.

Agronomic qualities and market values of the varieties used

The native varieties of sweet potato obtained in Nagcarlan are early maturing. According to information from old farmers who have been engaged in the production of sweet potato for a long time, the taste or flavor of these four varieties varies. The Inube variety has the best flavor, Minaynila, next best, Red variety, next, and Nilabanos, the poorest. These constitute the common types of camote available in the market. Of these varieties, the Inube commands the highest price because of its high quality of flavor and of the purple color.

METHODS

The planting materials

The planting materials were: (*a*) vines [2] or stem cuttings, (*b*) young terminal cuttings, (*c*) leaf cuttings and (*d*) root cuttings.

The cuttings called here young terminal shoots are also vine cuttings but they are so named to distinguish them from cuttings made of older parts of the stem.

Preparation of cuttings

The stems of each variety were taken from vigorous hills. Lengths of about one meter, measuring from the terminal and to the basal end, were cut. They were moistened with water at once and wrapped with banana leaves to prevent the leaves from wilting. The wrapped stems were sprinkled with water and laid overnight in a cool place to allow the leaves to regain their vigor.

Vine cuttings. Each vine cutting consisted of only two nodes obtained from the base of the cut stem. Only one cutting was taken from each stem. One-half of the total number of vine cuttings were soaked in 0.5 per cent potassium permanganate solution for about one minute and the other half were left untreated.

Young or terminal shoots. The cuttings were prepared from the terminal ends of the stems from which vine cuttings were taken. One-half of the total number of these cuttings were also soaked in 0.5 per cent potassium permanganate solution for about one minute, and the other half were not treated. Each cutting contained three to five nodes.

Leaf cuttings. The leaf cuttings were prepared from the vines from which vine cuttings and terminal shoots were taken. In their preparation, one of the methods of Isbell (1931) in the study of regeneration in leaf cuttings of sweet potato was followed. The whole leaf blade and the petiole were carefully removed from the vine, taking care not to include a portion of the stem. Also leaves cut across the midrib with the whole petiole were prepared. The cuttings were dipped for about thirty seconds in a 0.5 per cent potassium permanganate solution.

Root cuttings. The cuttings were prepared from ordinary roots and dipped in 0.5 per cent permanganate solution from 2 to 3 minutes. In the case of the Red variety, the roots were divided into sections because shoots had already developed when the materials were secured. Other roots were just split lengthwise without receiving any treatment.

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[2] In referring to different kinds of cuttings of sweet potato plant it is customary to speak of the stem as the "vine."

Planting the cuttings

In the nursery or propagation bed. As soon as all the cuttings were prepared, they were planted in a propagation bed consisting of sand and sandy loam in equal parts. The cuttings of the different varieties were handled separately to prevent mixing the planting materials. They were properly labelled to avoid confusion. The different kinds of cuttings were rooted in a nursery bed, before setting them on the field.

Setting the cuttings in the field. The plants were transplanted to the field as soon as they developed sufficient roots. Transplanting was done after a rain so that the young plants would have a good supply of soil moisture.

Care was taken in pulling up the young plants from the nursery bed so as to lessen root destruction. The planting materials were kept moist after pulling them from the bed up to transplanting. They were wrapped with banana leaves separately and then carried to the field. They were properly labelled so as not to mix the varieties.

The cuttings were planted in the field in rows, 2 meters apart and in hills, 2 meters apart in the row. Only one cutting was planted in each hill. The cuttings were planted in a slanting position.

The different planting materials were arranged in the field as follows: (*a*) vine cuttings used as control, (*b*) terminal shoot cuttings, (*c*) root cuttings and (*d*) leaf cuttings. Each clonal group was planted in a separate row.

The root cuttings of Red variety were planted on November 21, 1933. The vines, terminal shoots and root cuttings of Inube, Nilabanos and Minaynila varieties were planted on February 5, 1934, also the vines and terminal shoots of Red variety. The leaf cuttings of the four varieties were planted on July 16, 1934.

Harvesting

The plants of the different clons were harvested hill by hill. The roots harvested from each hill were counted and weighed and the largest roots measured and weighed. The crops of Red variety from root cuttings were harvested on May 20, 1934. The crops of Minaynila, Inube. and Nilabanos varieties from vines, terminal shoots and root cuttings were harvested on July 6, 1934, also the crops of Red varieties from vines and terminal shoots. The crops from the four varieties of the leaf cuttings were harvested January 20, 1935.

DISCUSSION OF RESULTS

Variation in sprouting in different clons

In clons produced from vine cuttings. The vine cuttings of the four varieties of sweet potatoes planted in the nursery bed sent out shoots within two to seven days. All did not grow. The vine cuttings were ready for transplanting in the field when about three weeks old in nursery bed. The cuttings that grew did not send out shoots or sprouts at the same time. There was not much difference in the degree of sprouting of the four varieties. Some of these cuttings belonged to the treated group, the others to the untreated groups.

The percentage of sprouting of the different varieties was of treated vines of Inube variety, 66 per cent, of the untreated vine, 61 per cent; of treated vines of Minaynila variety, 65 per cent, of untreated vines, 62 per cent; the treated vines of Nilabanos variety, 63 per cent, and untreated vines, 60 per cent; the treated vines of Red variety, 67 per cent; and untreated vines, 69 per cent.

In clons produced from root cuttings. In the Inube, Nilabanos and Minaynila varieties of sweet potato, it was observed that the shoots began to appear on root cuttings about a week after planting. The root cuttings could be planted in the field after three weeks in nursery bed. Not all of the root cuttings rooted. Some root cuttings, cut lengthwise and treated with permanganate solution, rotted.

The percentage of sprouting of the different varieties were: of treated roots of Nilabanos variety, 92 per cent, of roots cut lengthwise, 81 per cent; of treated roots of Minaynila variety, 78 per cent, roots cut lengthwise, 77 per cent; of treated roots of Inube variety, 73 per cent, of root cut lengthwise, 79 per cent; of the treated roots of Red variety, 83 per cent, of root cut lengthwise, 80 per cent.

In clons produced from terminal shoots. The terminal shoots could also be planted in the field three weeks after sowing in the nursery bed. Not all the shoot cuttings grew. The cut portion rotted and failed to send out roots.

The percentage of sprouting of the different varieties were: of treated terminal shoots of Red variety, 60 per cent, of untreated terminal shoots, 65 per cent; of treated terminal shoots of Inube variety, 60 per cent, of untreated terminal shoots, 58 per cent; of the treated terminal shoots of Minaynila variety, 60 per cent, of untreated terminal shoots, 64 per cent of the treated terminal shoots of Nilabanos variety, 68 per cent of untreated terminal shoots, 61 per cent.

In clons produced from leaf cuttings. The sending out of shoots took place, in from six to seven weeks after sowing. The base of the petiole formed a callus and roots were then sent out. As soon as the roots came out, shoots came out also from the callus formed. Most of the leaf cuttings produced roots but failed to send out shoots.

The percentage of sprouting of the different varieties was: of cuttings made of whole leaf of Nilabanos variety, 29 per cent; of leaf cut across midrib, 27 per cent; of cuttings made of whole leaf of Minaynila variety, 29 per cent; of leaf cut across midrib, 31 per cent; of cuttings made of whole leaf of Inube variety, 35 per cent; of leaf cut across midrib, 29 per cent; of cuttings made of whole leaf of Red variety, 33 per cent; of leaf cut across midrib, 28 per cent.

Variation in production of ordinary roots in different clons

The root formation in the different cuttings took place after several days. It was observed in the Red variety that the roots began to swell about seven weeks after planting. In the Nilabanos, Inube and Minaynila varieties, swelling of roots was observed six weeks after planting. The swelling in the vines and terminal shoots of roots was observed about six weeks after planting. In the leaf cuttings, swelling of roots was observed about ten weeks after planting. In making the observations, care was taken not to destroy the roots penetrating into the soil. A slight scratch-of the soil was made in determining whether roots were beginning to form. Only five cuttings of each treatment were examined, taking note only when the roots began to swell.

Variations in stem characteristics in different clons

It was observed that the plants in the different clons from each variety have the same stem color. In Inube clons, the color of the vine was purple or purplish green. The Minaynila clons had green vines. The Nilabanos clons had light green vines. The vines of the clons of the Red variety were green.

Variation in certain leaf characters in the different clons

In clons produced from vine cuttings. The shape and color of the leaves varied. In the Minaynila and Inube clons, the number of serrations varied from three to five. The leaves of the Minaynila and Red clons had only lobe. The color and shape of the leaves varied. The color of the youngest leaves of the Red, Nilabanos and Minaynila clons were either light purple, greenish purple or light green. In the Inube clons, the youngest leaves were either deep purple or purple in color. The leaves of the Minaynila clon turned yellowish green in about four months and the other three varieties in five months.

In clons produced from root cuttings. The Inube clon had deep purple, purple, or deep green leaves. The deep purple color was observed on the young leaves at the terminal shoots. In the field, the leaves of the clons of all the varieties began to turn yellowish green within four months. This yellowing of leaves was very marked in the Minaynila variety. The Red clons had light purple, purple or green youngest leaves. The Nilabanos clon had light green or light purple youngest leaf. The Minaynila had purple, light green or green color youngest leaf.

In clons produced from terminal shoots. The color and shape of leaves varied. The color of leaves in most of the young leaves was light purple, deep purple or light green. The leaves of the plants turned yellow in about four months in the same way as those of plants from root cuttings. The Red clons had light purple, purple or green youngest leaves. The Nilabanos clon had light green or light purple youngest leaf. The Minaynila clon had purple, light green or green youngest leaf. The Inube clons had deep purple, purple or deep green youngest leaf.

In clons produced from leaf cuttings. The Inube clons had deep purple, greenish purple young leaf. The Red clons had purplish green, green or light purple youngest leaf. The Minaynila clon had light purple or green youngest leaf. The Nilabanos had light purple or green youngest leaf.

Large bud variations observed. In the four varieties studied, the vegetative variation was observed in the leaf lobing and tuber characters. The typical Inube leaf bears five lobes. Leaf variants, numbers 1 to 6, differ in the number of leaf lobing. Three lobes of each leaf of these varieties were smaller than the fourth one. Variants, numbers 2, 3 and 4 had five lobes and variant number 6 had three lobes. The size and shape of each of the lobes of these leaf variants also appeared different. The different observations were made on one plant.

The typical leaf of Nilabanos variety is shown as having only one lobe. Two cases were found differing from the typical leaf. Variant number 1 had a small lobe on one of the sides of the leaf. Variant number 2 had two small lobes, one on each side of the leaf. Variant number 3 had two small lobes, one on each side but the shape of the leaf was different from that of variant number 2. Variant number 4 had two lobes on one side and one lobe on the other side of the leaf.

The typical leaf of the Red variety was entire. Deviations from this were found. Variant number 1 had one lobe on one side of the leaf. Variant 2 had one lobe on one side of the leaf also, but the shape differed from variants 1, 3, 4 and 5. Variant number 3 had only one lobe but the shape differed from the typical leaf. Variant numbers 4 and 5 each had one lobe on one side of the leaf and another lobe on the other side, but they differed in shape.

The typical leaf of variety Minaynila had three lobes. The variants observed had a different number of lobes. Variant number 1 had six lobes, differing from variants 2, 3, 4, 5 and 6. Variants numbers 2, 4, 5 and 6 had five lobes each but they differed in shape of leaf lobing. Variant number 3 had four lobes differing from variants numbers 1, 2, 4, 5 and 6. These variations were observed under field conditions. The characteristic leaf variant was confined to a hill which strongly suggests that this variation would appear also in the next asexual propagation. The other asexual means of planting, as root cuttings, leaf cuttings and terminal shoots failed to show any marked bud variation.

Variation in root characteristics. The number of roots, the weight of root, diameter of largest root, weight of largest root and the number of rounded roots produced by the different clons were determined.

The mean values for these characters in all varieties in both the roots and vine cuttings were not significantly different. In case of the leaf cuttings, these values were considerably lower than those found in vine cuttings and the difference was statistically significant. This difference may be attributed to the fact that plants grown from leaf cuttings at the age of six months had not yet produced marketable roots.

The plants arising from terminal shoots of Inube gave lower values in these characters than the control or vine clon, but the difference was significant. In Nilabanos and in Minaynila these apparent equalities in the mean values of agronomic characters of the roots were noted.

In the case of the Red variety the mean values for the different root characters were slightly lower than those produced by the check, but again the difference was not significant.

It would seem that with the exception of the progeny from leaf cuttings which was markedly different in the mean values of root characters from that of vines, other asexual progeny within the variety did not show any significant variation. The variations noted may be considered only a temporary modification.

Clonal variability among varieties. The different methods of propagation employed in each variety showed different results. In case of clons derived from root cuttings the varieties may be arranged in a descending order, as follows, based on number of tubers produced per plant: Red variety, Minaynila, Nilabanos and the Inube. In case of clons from leaf cuttings, the order was Minaynila, Inube, Red variety and Nilabanos for mean number of tubers. In case of clons from terminal shoots, the order was Minaynila, Inube, Nilabanos and Red variety. In case of clons from vines, the order was Red variety, Nilabanos, Inube and Minaynila. The varietal differences for the mean number of roots were not significant. No attempt was made to compare the varieties as to mean weight and size of tubers produced by the different clonal groups because some clons did not produce measurable tubers or roots at the age of six months in the field.

Large variations observed. In these experiments, the search for large bud variations in roots was made on harvest from individual plants of different clonal groups. The roots of each clon were examined by cutting the roots into sections so as to find any marked changes as to color which characterize the different sweet potato varieties. About 4000 roots of each variety or a total of 1,600 roots for the four varieties were examined individually. It was found that clons produced by vine cuttings of Inube variety which had solid purple flesh on cross sections gave rise to four different flesh color types. These variations represent differences in distribution of flesh pigmentation.

Variant 1 had solid purple color of flesh typical of the parent Inube variety. Root variants numbers 2, 4 and 5 had light purple color at the center. In center of variants 2 and 5 there was long patch of purple color. The white color of variants numbers 2, 4 and 5 encircled the light purple color at the center. Bud variant number 4 had white circular color with spot at the center surrounded by purple color. The white color which surrounds the light purple had scattered purple stripes. Variant number 3 had purple color at the center but the distribution of the color was uneven. This purple color was surrounded with light purple color with scattered purple stripes.

SUMMARY AND CONCLUSIONS

In these experiments attempts were made to compare the variabilities in different clonal progeny of four varieties of sweet potato and to record bud variations or vegetative variations which may arise through asexual propagation. The results may be summarized as follows:

1. The four varieties which differ in skin and flesh color of the roots, as well as in leaf characteristics, did not show any appreciable degree of variability when propagated by root cuttings, leaf cuttings, terminal shoots and vine cuttings. The clonal variabilities shown by clons arising from root cuttings, leaf cuttings and cuttings of terminal shoots were compared with those of the clon arising from vine cuttings which is the most common plant material used in the commercial propagation of sweet potato.

2. Clons six months old arising from leaf cuttings cannot be compared in respect to storage roots produced, with other clons of the same age, because at this age the roots formed by the leaf clons were not of marketable grade. With the exception of the clonal progeny of leaf cuttings, all other progeny produced marketable storage roots.

3. The variations in root characteristics of root clons, leaf clons, terminal shoot clons, and vine clons of each variety were compared on the basis of coefficient of variability and using vine clons as the basis of comparison. It was found that the vine clons gave a greater or less degree of variability than, or similar degree of variations to the other clons within a variety. Therefore, the variations observed in the present studies were not of a degree that would make selection effective.

4. In all of the varieties studied there was no significant difference in the mean number of roots, weight of roots, length and diameter of largest root of the root clons, terminal shoot clons and vine clons. The leaf clons were not compared as the roots formed were not marketable.

5. Taking the mean number of roots produced per plant as a basis in different clons, the varieties may be grouped in descending order as follows:

(*a*) Root clons: Red variety, Minaynila, Nilabanos, and the Inube. (*b*) Leaf clons: Minaynila, Inube, Red variety, and Nilabanos. (*c*) Clons from terminal shoots: Minaynila, Inube, Nilabanos, and the Red variety. (*d*) Vine clons: Red variety, Nilabanos, Inube and Minaynila.

6. Two distinct types of large bud variations were observed in plants propagated by vine cuttings. The first type consisted of a leaf variation in shape and lobing found in the four varieties used. The second consisted of root variation on flesh pigmentation and was recorded in only one variety, the Inube.

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ABSTRACT[1]

Extraction of starch from sweet potato using College cassava graters. PORFIRIO R. CARANDANG. (*Thesis presented for graduation, 1933, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 498; Experiment Station contribution No. 1123.*)—The author worked on the extraction of starch from sweet potato using College cassava graters. Six varieties of sweet potato were used; namely, Samar Big Yellow, Pute, Pirurutong, Manila Pula, Binurong and Cebu. The three different College cassava graters were used in extracting the starch from the sweet potato roots. For convenience, these graters are named: Grater No. 1, Grater No. 2 and Cuzner Grater. Graters No. 1 and No. 2 are constructed on the same principle and are operated by foot power. The Cuzner Grater is more complicated in construction. The method of operating it is the same as Graters No. 1 and No. 2 but the power is furnished by a 3 h. p. motor.

The sweet potato roots of each variety grated in each grater were of about the same age and size and were given the same treatment before grating. Five samples of 5 kilograms each of each variety were used in Graters No. 1 and No. 2. The amount of roots grated in each sample in the Cuzner Grater was more than that used per sample in either Grater No. 1 or No. 2. The method of extraction of starch was the same in the three different College graters, except that in the Cuzner Grater extraction was done more systematically and on a larger scale. All subsequent treatments of the starch extracted were the same.

The following results were obtained by the author:

1. Among the six varieties used, the Cebu variety gave the highest percentage of extraction of starch; Binurong, second; Samar Big Yellow, third; Pute, fourth; Pirurutong, fifth; and Manila Pula, the lowest.

2. Using College Grater No. 1 and including all varieties, the average cost of extracting one kilogram of dry starch was 18 centavos; using Grater No. 2, 12 centavos; and using Cuzner Grater, 5 centavos. The total cost of production per kilogram of dry starch

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[1] Abstract prepared as part of theme work required in English 3a, College of Agriculture.

with the use of Grater No. 1 ranged from 27-54 centavos; it was higher than with Grater No. 2, which ranged from 26-41 centavos, or with the Cuzner Grater, which ranged from 23-51 centavos. These differences in the cost of production were due to the differences in efficiency of the graters.

3. Although grating was much faster with the Cuzner Grater than with either of the other two graters, the cost of production per kilogram of dry starch with this grater was a little more than that of Grater No. 2; the Cuzner Grater has a greater depreciation and higher interest on its value in addition to the cost of fuel used in operating it.

4. Because of the low percentage of starch content of the roots of sweet potato, it was recommended that it is not profitable to extract starch from its roots with the use of the College graters.

—*Abstract by Felix N. Natino*

Faculty Committee on Student Welfare on the job, helping new registrants orient themselves.

COLLEGE AND ALUMNI NOTES

At the one hundred and twelfth monthly meeting of the Los Baños Biological Club on June 25, three papers were read, as follows: (1) Mr. Mamerto Sulit on wild ornamental plants of the Philippines; (2) Dr. Dionisio I. Aquino on base exchange properties of certain Philippine soils; and (3) Drs. Miguel Manresa and Mariano Mondoñedo on resistance of the Berkjala pig to hog cholera. Doctor Aquino's paper was published in the July issue of *The Philippine Agriculturist;* Drs. Manresa and Mondoñedo's appears in the present number.

According to recent advices received at the College, Dean B. M. Gonzalez was reëlected to the board of directors of the National Development Company on March 10, 1936, on nomination of President Quezon.

Capt. Amado Martelino, F. A., U. S. Army, assistant commandant in charge of the Department of Military Science, University of the Philippines, at Los Baños, left on July 22 for Fort Leavenworth, Kansas, where he has been detailed to take the command and general staff course. Capt. Pablo Suarez, Philippine Army, relieves Capt. Martelino at Los Baños.

Conrado B. Uichanco, '33, and Flaviano Olivares, '36, have been appointed probationary third lieutenants in the Philippine Army. They are at present attached to the Department of Military Science at Los Baños. Another recent Philippine Army appointee is probationary third lieutenant Proceso E. Alcala, '33, assistant in agronomy at this College, who is now detailed at the army training school in Baguio in order to undergo further instruction in military science.

Mrs. Harriett L. Richards and Mrs. Josefa D. Diaz, until lately on the staff of the Department of Agricultural Education, have been detailed to the Department of English, of which Mrs. Richards has been designated in charge.

IN MEMORIAM

AMBROSIO VALUANZA SAN PEDRO, B.S.Agr., 1930, M.S.A., 1932, University of the Philippines. Born March 20, 1908, in Navotas, Rizal Province. Entered the College of Agriculture, June 11, 1926; worked his way through as a student. Marked distinction in scholarship in 1928 and 1929, standing second in class. Baker Memorial Scholar in 1930. Assistant in agronomy, Department of Agronomy, 1930 to 1935. Assistant in horticulture, Department of Agricultural Education, since 1935. Died on July 6, 1936. at Los Baños, Laguna Province.

DEAR COLLEAGUE[1]

Le Gentil, the French astronomer, who visited the Philippines in 1761 and 1769, observed that in science Spain was some fifty years behind France; and the Philippines, fifty years behind Spain. He must have been a little too harsh in his judgment, which was possibly more or less biased. It should be recalled that foreigners were not welcome at that time and, if they succeeded in entering this country, they became the subject of suspicion as possible heretics. Le Gentil's brief stay in Manila was, therefore, anything but pleasant, what with the peering eyes of spies, in the guise of sociable friends, to see if his curious experiments had something to do with the devil. Consequently, he occasionally took advantage of an opportunity to retaliate. At one time he dressed the figure of his Cartesian diver as a monk and made it perform acrobatic stunts and exhibition dancing in its liquid bath.

But the fact can hardly be disputed that scientific progress in the almost four centuries under Spain seems to have all but forgotten the Philippines in its itinerary. Spanish colonial ability and energy were bent on other pursuits. Contrary to Jagor's (1860) conclusion, in so far as scientific work was concerned, they were not even centuries of wasted opportunities. There was no opportunity given, to speak of, that could be wasted. What there was of accomplishment along research lines that was not the work of visiting scientists was done almost exclusively by a handful of resident Spaniards.

Of course, viewed in absolute terms, some injustice from ill-considered inferences may be committed against Spain. It is hardly possible to surmise how Spain might have acquitted herself if the universally more science-minded twentieth century had found her still ruling the Philippines. But destiny was to assign to the American people the responsibility of drafting the Philippines into a modern world's great whirlpool of research activities. The early American pioneers in science in the Philippines—Flexner, Freer, Worcester, Ahern, Whitford, Strong, Heiser, Edwards, Dickerson, Barber, Mitzmain, Vedder, Baker, Merrill, and Copeland, to mention only a few—

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[1] General contribution No. 529.

THE PHILIPPINE AGRICULTURIST, VOL. XXV, NO. 4, SEPTEMBER, 1936.

laid down the first building blocks of what was by slow degrees to develop into a far-reaching Philippine institution.

It was found soon after the inauguration of the varied research activities that a handful of American scientists at a time could not hope to make much impression on the vast sea of problems that began to challenge the researcher. More workers were needed, who, moreover, should stay long enough in this country, in order to insure thoroughness as well as continuity. Questions of gratitude aside, it could not have been a purely altruistic motive that prompted the training of a sizable army of Filipino scientists. The phenomenal progress that the Philippines made in the thirty-seven years under the United States must, in a measure at least, be credited to the achievements of science in these islands.

The present contingent of Filipino researchers is scarcely a generation old. In educational preparation, which they received in the best of Philippine, as well as American or European, centers of learning, the Philippines need not be apologetic about her own scientists. Scientific methods demand a new orientation, which, in many respects, differs fundamentally from that which guided our people for centuries. Worthwhile scientific results take time in obtaining, especially with the existing, often meager, facilities. Doubtless what has been accomplished so far, in the solution of health problems, improvement of crops and livestock, control of pests and diseases, rationalization of farm practices, development and promotion of new industries, and hundreds of other tangible results, provides as full an opening chapter as might be expected in this early contemporary history of Philippine science.

We have not yet passed that stage when the maintenance of research work ceases to be an exclusive responsibility of the government. With the possible single exception of the sugar industry in its more prosperous days, private enterprises have not reached that degree of growth and organization when they could include research laboratories as an essential part of their business scheme. Scientific activities in the Philippines, therefore, are almost entirely carried on at public expense, and the scientists are nearly all on government payroll. Some of the heaviest sufferers since the depression, when retrenchment became necessary in our governmental machinery, have been our already few struggling research centers. It does not seem right that this should be so, considering that scientific establishments do not belong to the luxury class. They are not supported merely to put up an appearance of keeping up to date with current style among advanced nations. The question involved is not so much that research pays dividends, which has, of course, often been proven. Every move to cripple research work is a bid for the return to conditions at the time of Le Gentil's visit. It is certainly not encouraging research when all too often our scientists have not even the chance to show that they are the proverbial poor workman, owing to severe restriction of funds. Moreover, in an effort constantly to justify expenditure of public money, there has unfortunately begun to develop a tendency to restrict research activities to projects that would be of immediate practical application. By so doing, we are apt to overlook Pasteur's dictum that "it is characteristic of science incessantly to reduce the boundaries of unexplained phenomena." Time and again, somewhere beyond these boundaries are found unpredictable surprises, the discovery of some of which has resulted in profoundly changing the aspect of human civilization. Limitation of research programs to very narrowly circumscribed fields, usually in response to particular emergencies, cannot but exert a dangerously sterilizing influence on scientific work in the Philippines. As Secretary Henry A. Wallace so ably presents it in his 1935 annual report for the United States Department of Agriculture: "Research of this type, for objects well defined in advance, is extremely valuable, and will always be necessary. But it is not the only type of research which agriculture needs. In fact, such research is in the nature of superstructure. It needs much more foundation research to establish laws and principles. Science is exploration and should not be confined to territory that can be mapped in advance. One might as well equip an exploration party and forbid it to break new ground." So clear an exposition of an attitude in the right direction needs no further elaboration. A practical-minded American states the case for research in his country. He might well have written those very words for the Philippines, with a further reminder that it takes the background of more than one single generation of scientists to breed a Mme. Curie, a Michelson, an Einstein, or a Kitasato, and that really great scientific discoveries usually do not merely happen to fall in the way of the researcher, especially if his mind is often taken away from his work by the bugaboo of finding himself thrown into the street some day as a result of "reorganization."

L. B. U.

DISEASES OF COTTON IN THE PHILIPPINES: I. SCLEROTIUM STEM ROT, WITH NOTES ON OTHER DISEASES[1]

M. S. CELINO
Of the Department of Plant Pathology

WITH SIX TEXT FIGURES

On March 20, 1935 a diseased cotton seedling of the variety Pima Egyptian was submitted to the Department of Plant Pathology by Doctor Eulalio P. Baltazar of the Department of Agronomy, College of Agriculture, Laguna. The specimen which was 25 centimeters long and with a stem diameter of two and one-half millimeters was wilted and appeared dead. It showed an advanced stage of a fungous attack, the lesion in the stem extending from the base (at about the ground level) to nearly six centimeters upward. Except for the presence of bits of mycelium no other structures of the parasite were found on the specimen. Series of isolations made from the borders of infection yielded a *Sclerotium,* the characteristics of which show striking similarities to those of *S. rolfsii* Sacc.

THE DISEASE

History, distribution and economic importance

Members of the genus *Sclerotium* have been frequently reported as causes of various diseases of plants. Of the species known in the Philippines, *Sclerotium rolfsii* Sacc. is the most widely distributed and is known to cause infection on not less than forty different host plants. This may be seen in table 1.

The *Sclerotium* disease of cotton has not hitherto, been reported in the Philippines. Our knowledge of the cotton diseases in this country began with the brief description of the angular leaf spot caused by *Bacterium malvacearum* EFS. and a rust of cotton due to the fungus *Kuehneola desmium* (B. and Br.) Syd. (= *Uredo desmium* [Berk. and Br.] Petch) made by Reinking of the College of Agriculture at Los Baños. In 1921, Welles also of the College of Agri-

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[1] Experiment Station contribution No. 1130. Prepared in the Department of Plant Pathology under the direction of Dr. G. O. Ocfemia.

The portion which deals with *Sclerotium* stem rot was read before the Los Baños Biological Club, August 29, 1935.

Received for publication December 6, 1935.

culture reported the anthracnose of cotton as a new disease in the Philippines. Baltazar (1934) mentions cotton mosaic (virus), *Fusarium* wilt, seedling rot or damping off and root gall as among the cotton diseases which commonly occur in the College of Agriculture. Clara (1935) of the Philippine Bureau of Plant Industry at Manila reports the following diseases not previously known in the Islands: *Helminthosporium* blight (*Helminthosporium gossypii* Tucker), *Cercospora* leaf spot (*Cercospora althaeiana* Sacc.), club leaf (cyrtosis) and another leaf disease with which *Alternaria* sp. is associated.

In the United States, Ezekiel and Taubenhaus (1931) of the Texas Agricultural Experiment Station reported a disease of young cotton plants caused by *S. rolfsii.* Walker (1930) working in Florida, states that the same species occasionally occurs on cotton bolls close to the ground. As early as 1897 Rolfs found *S. rolfsii* on cotton. This report was much later corroborated by Taubenhaus (1919) and Weber (1931) who list cotton (*Gossypium hirsutum* L.) as one of the hosts of *S. rolfsii.* According to Cook (1925), the fungus is also present in Porto Rico but does not affect cotton seriously. Bertus at Peradeniya, Ceylon, reports that in 1927 he successfully inoculated Cambodia cotton with pure culture of *S. rolfsii* isolated from groundnut, *Arachis hypogaea* L.

Symptoms

The disease attacks the plant usually on the stem at about the ground level or just below it. The bark in the affected region turns reddish brown, shrinks slightly and finally rots or decays. The rotting develops readily around the stem and then from the base to a few centimeters upwards. It is not uncommon to see a cotton plant completely girdled at the base of the stem. Under conditions of high humidity white fungous growths and sclerotial bodies develop on the surface of the host and on the ground close to the plant (fig. 1). In severe attacks the infection extends to the woody portion of the stem. The death of the plant at the base is later followed by the wilting of the leaves. Occasionally, owing to the death of the cells and the gradual weakening of the tissues in the region of infection, the stem breaks and the whole upper portions of the plant topple over.

CAUSAL ORGANISM

Method of isolation

The fungus was isolated in pure culture by the ordinary tissue-culture method. Small sections of the bark were prepared from the border of infection. These sections were surface sterilized in mercuric bichloride solution (1:1000) then washed in series of sterile water in test tubes and finally plated out on solidified potato-dextrose agar in Petri dishes, four sections to each dish. In four days three separate growths of the fungus, each free from any contamination were obtained.

Morphology

Mycelium. The mycelium is white, fast growing, often in strands, coarse, especially the hyphae at the edge of the colony, septate, vacuolate to almost empty when old and with knee-like projections or clamp connections. The diameter of the hyphal cells in culture varies from 3.5 to 9 μ, the majority of the cells having a diameter ranging from 4.2 to 6.3 μ. The average diameter of 50 hyphal cells measured is 6.01 μ. According to Bertus (1927) the hyphae of *S. rolfsii*, groundnut (*Arachis hypogaea* L.) strain, vary in diameter from 5 to 7 μ in culture. Pereira (1922) obtained from 4 to 6 μ for the rice strain in the Philippines. Atienza (1927) gave 2.88 to

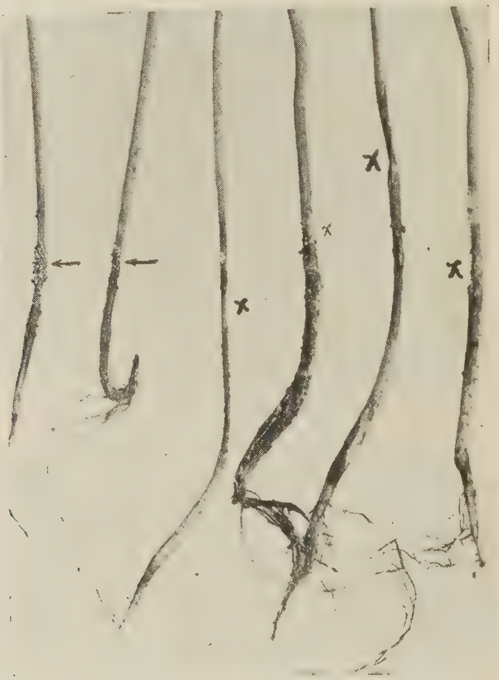

Fig. 1.—Stems of young cotton plants showing the symptoms (x) and signs of the disease. Note masses of sclerotial bodies of the fungus indicated by arrow heads on the two stems on the left.

9.36 μ as the range in the diameter of the mycelium of *Sclerotium rolfsii* for tomato strain and 3.24 to 7.56 μ for the pepper strain. Palo (1933) reported 1.60 to 8.30 μ with an average of 4.58 μ for *S. rolfsii*, pepper strain; 1.50 to 9.13 μ with an average of 4.51 μ for the rice strain; and 1.50 to 8.35 μ with an average of 4.6 μ for the tomato strain.

Sclerotial bodies. The sclerotia are generally round, smooth, white when young, later turning light yellow and then brown to dark brown with age. Young sclerotia begin to be visible in culture on the fourth day. They are produced abundantly often numbering between 200 and 350 sclerotial bodies in one Petri dish of about 9 centimeters in diameters. As observed in culture, many sclerotia are usually produced near the edge of the dish. In a few instances two or more sclerotia fuse forming larger masses, which measure from two to two and seven-tenths millimeters in length. Measurements of 60 mustard-seed-like sclerotia from potato-dextrose agar culture gave a range in diameter from 0.6 to 1.5 mm. with an average of 0.984 mm. The majority of the sclerotia have a diameter of one millimeter. The figures reported by Fajardo (1933) for *S. rolfsii* vary from 0.5 to 1.6 mm. with most of the sclerotia having a diameter between 0.8 and 1.0 mm. Bertus gave from 1 to 2 mm. as the range in the diameter of the sclerotia of the groundnut strain in Ceylon. On sweet potato he obtained abnormally large sclerotia up to eight millimeters in diameter. On a dadap (*Erythrina lithosperma* Bl.) leaf soaked in sugar solution aggregations of sclerotia up to 1 centimeter in diameter were produced. Pereira obtained for the rice strain figures ranging from 0.76 to 1.15 mm. on potato agar; 0.63 to 1.25 mm. on corn meal and 0.70 to 1.15 mm. on rice plants. According to Atienza, the sclerotia of the tomato strain vary in diameter from 0.75 to 2.27 mm. on corn meal, 0.69 to 1.48 on potato-dextrose agar, and 0.39 to 0.86 on the host plants. Those of the pepper strain measure from 0.54 to 1.35 mm. on potato-dextrose agar, 0.82 to 2.2 on corn meal and 0.29 to 0.92 on the host plants. As may be noted above, the writer's figures for the fungus *Sclerotium*, cotton strain, agree very closely with those of Fajardo for the *Delphinium* strain, with those of Atienza for the tomato and pepper strains grown on potato-dextrose agar and with those of Pereira for the rice strain grown either on culture media or on the rice plant. They are slightly smaller than the figures reported by Bertus.

Cultural characters

In the isolation of the cotton *Sclerotium* in pure culture, the writer obtained three separate fungous growths, each free from any contamination. Transfers were made from each of these growths and were labeled separately as cultures CA, CB and CC. Subsequent platings were made from these cultures to determine if this species is made up of sexual strains. According to Taubenhaus (1919), who reported the existence of the plus and the minus strains in *S. rolfsii* which he isolated from cotton, sexual act was shown by the fungus when it formed in Petri dish cultures, sclerotial bodies at the line of union of two opposite colonies of different sex strains. He further stated that repeated trials showed that whenever a plus and a minus strain were plated in the same dish, sclerotia always formed at the line of union of the fungous colonies. But when each strain was plated separately few or no sclerotia developed.

On April 4, 1935, dish cultures of the fungus were prepared as follows: two sclerotial bodies, one each from transfers CA and CB, were plated in one dish. Similarly, cultures from transfers CA and CC and from transfers CB and CC were set. Other series of dish cultures were prepared on April 6, 8, 11 and 16. In these trials it was noted that the fungous hyphae from two opposite growths in each dish such as CA and CB; CA and CC; and CB and CC extended across and mingled freely with sclerotia formed at no definite place in the dish. These results show that this Philippine species of *Sclerotium* on cotton is not composed of plus and minus strains. In similar experiments the writer found that neither of the strains of *S. rolfsii* which were isolated from abacá (*Musa textilis* Née), eggplant, lettuce and soybean exhibited the sexual act in the manner described by Taubenhaus.

The phenomenon of aversion as explained by Nakata (1925) and Stevens (1931) was, however, strongly manifested between the cotton *Sclerotium* and any strain of *S. rolfsii* isolated from abacá, eggplant, lettuce, nanka, *Christisonia* and indigo (*Indigofera*), also between the cotton strains and the mango *Sclerotium* (*S. delphinii*) and between any two strains of *S. rolfsii* already referred to. The fungous hyphae from two opposite transfers ceased growing when they were about to meet, thus leaving a narrow clear region between. The mycelium along this region became finer, more slender and with the tips bent slightly backward or deflected sideways. Quite a different cultural behavior was noted in the case of the cotton *Sclerotium* and *S. rolfsii* from soybean. The hyphae from opposite growths extended across and mingled freely. No fungus-free region was formed between the two growths and sclerotial bodies appeared at random in the dish. In all probability the cotton and soybean strains are the same. This conclusion is based on the findings of Nakata and Stevens who reported from their studies on *Sclerotium rolfsii* that antagonism or aversion occurs between fungous growths of different strains but not between growths of the same strain.

Proof of pathogenicity

On March 25, 1935, five cotton seedlings, 30 to 40 centimeters tall were inoculated by applying the inoculum on the uninjured stem at ground level or just below it. The checks were treated likewise but with sterile potato-dextrose agar only. The treated and the check plants were kept in the damp chamber for four days, after which they were transferred to the shade for further observation. On March 30 all the inoculated plants showed infection of varying degrees. Tufts of fungous hyphae and young sclerotia developed on the surface of the affected stems and on the soil around them. Two of the five inoculated plants died of the disease on April 5. The others recovered gradually. It was noted that recovery was hastened when the plants were exposed to sunlight and the soil kept just sufficiently moist for the growth of the cotton seedlings.

The parasite was easily reisolated in pure culture. On April 9, cotton seeds which had been delinted with sulfuric acid and the surface sterilized with mercuric bichloride solution (1:1000) for one minute and rinsed with sterile water were planted in sterile soil previously inoculated with the cotton *Sclerotium*. The inoculum consisted of bits of actively growing mycelium and sclerotial bodies of different ages. Cotton seeds which were planted in sterile or uninoculated soil served as control. All the lots were kept in the damp chamber.

On April 20, one seedling in the inoculated lot fell over owing to the rotting of the stem. Wefts of fungous growths covered a portion of the dead stem and here and there on the soil, young sclerotial bodies of the fungus were forming. Three days later several seedlings in the same lot became infected. They rotted at the base, fell over and died. All the seedlings in the control lot remained healthy throughout the experiment (fig. 2).

Trials were made on April 22 to infect cotton plants that were already flowering or about to flower. The fungus, consisting of bits of young mycelium and sclerotial bodies, was applied at the base of the uninjured stem. All the inoculated plants became infected in five to six days under damp-chamber conditions. Outside of the chamber, however, the growth of the fungus slowed down and was inhibited when the plants were exposed to light. Of the ten plants inoculated eight recovered in one week and produced fruits normally afterwards. One recovered quite slowly and became stunted. It produced flowers and fruits although late and less in number. Only one of the ten plants failed to recover. On account of the death of the bark and the gradual weakening of the tissues in the region of infection the stem collapsed. All the upper portions of the plant fell to the ground.

Cross inoculation tests showed that the cotton strain equally attacked abacá, eggplant, lettuce, peanut, tomato, rice and soybean. There is little doubt that it will also attack other plants. Similar experiments using separately strains of *S. rolfsii* from abacá, eggplant, lettuce, peanut, nangka, *Christisonia,* soybean and indigo showed that cotton seedlings were as highly susceptible to any of these strains as to the cotton strain (table 2). In the United States, Ezekiel and Taubenhaus (1931) proved that "*S. rolfsii,* whether isolated from cotton or from carrots, may cause a stem rot of young cotton plants."

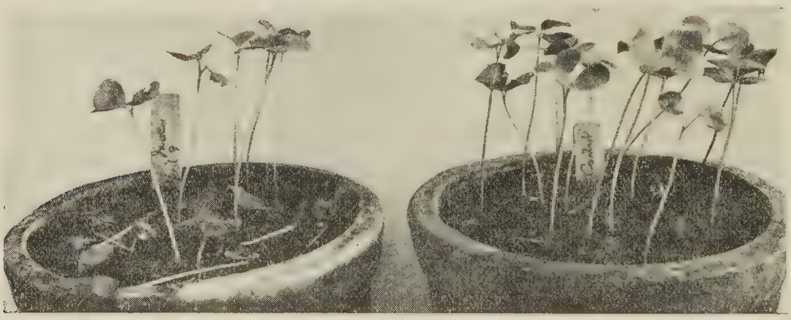

Fig. 2.—Showing the effects of *Sclerotium rolfsii* on cotton seedlings. Note the difference between the inoculated and the control lots.

These experiments (table 2) established the pathogenicity of the cotton *Sclerotium.* It appears, however, from the results obtained that although the fungus attacks both the seedlings and mature cotton plants, the seedlings are the ones most readily affected. Fully grown plants became infected quite rarely. These findings corroborate those reported by workers in other countries. Inoculation experiments conducted by Bertus in Peradeniya showed that cotton seedlings seven days old gave six successes out of nine inoculations or 67 per cent infection. Cotton plants a little over four months old did not get the disease. This author concluded that certain seedlings are susceptible to *S. rolfsii* in the young stage but become immune when older. This conclusion is consistent with that of Ezekiel and Taubenhaus who state that "*S. rolfsii* probably attacks older cotton plants only rarely, although it may destroy young seedlings or plants ranging from a week to 10 weeks old."

Taxonomy

Studies of the morphology, physiology and cultural behavior of the cotton *Sclerotium* show, in general, many striking similarities to *S. rolfsii* as reported by various authors (Atienza, 1927; Bertus, 1927; Pereira, 1922; Taubenhaus, 1919; Ezekiel and Taubenhaus, 1931; and Fajardo, 1933). Certain peculiar characters of *S. rolfsii* such as the characteristic mode of hyphal branching and the formation of hyphae in strands were observed also in the cotton strain. Measurements of both the mycelium and sclerotial bodies of the cotton strain and those of *S. rolfsii* agree closely. Incidentally, also inoculation tests showed that the cotton *Sclerotium* attacked with equal severity other plants that had been previously reported hosts of *S. rolfsii.*

The cotton *Sclerotium* referred to in this paper is therefore considered identical with *S. rolfsii* that attacks abacá, eggplants, lettuce, peanut, soybean and various other plants in the Philippines.

SEASONAL OCCURRENCE AND DISSEMINATION

As may be seen in table 3, *Sclerotium rolfsii* occurs in many places in the Philippine and causes various diseases of plants. This parasite, however, develops and causes infection often only under conditions of high humidity. On account of this environmental requirement the fungus does not appear in numbers sufficiently great to cause an epiphytotic. It causes, nevertheless, certain losses every year and for that matter its presence in the field is highly objectionable. The parasite grows actively in the field at the time when many of the host plants are in the stage most susceptible for infection.

During the dry weather infection or production of disease seldom occurs at the College of Agriculture. Dry air and soil do not favor the growth of the fungus. Consequently the parasite remains inactive probably as sclerotial bodies. After the rains in May and June the sclerotial bodies germinate and the active life of the organism commences. At the beginning the fungus assumes a saprophytic life. The parasitic habit begins as soon as susceptible plants in the field become available.

Dissemination of the fungus from one locality to another is easily accomplished especially in the absence of strict sanitary measures. *Sclerotium rolfsii* is of world-wide distribution and with not less than forty different host plants in the Philippines. For this reason transfer of the fungus from one host to another is almost always unknowingly effected. The sclerotial bodies of the fungus afford excellent materials for dissemination with the soil or diseased planting materials.

CONTROL

The severity of the *Sclerotium* disease in seed beds can be greatly minimized by soil sterilization. The writer found that seeds of cotton, tobacco, tomato, radish, eggplant and lettuce that were planted in soil previously inoculated with *Sclerotium* and then heated to 100°C. for 30 to 60 minutes did not show any *Sclerotium* infection.

The most practical method of control of the disease in the field should aim at eradicating or reducing to the minimum the amount of inocula in the plantation. Remove as soon as detected all affected plant parts and burn them including the soil in their immediate vicinity. If infection is severe, spray with any fungicide like Bordeaux mixture and cover the soil about the infected plants. Plants badly infected showing that they have no chance to recover should be eliminated from the plantation and destroyed with the parasite. This elimination will reduce considerably the materials for future infection. In localities where the disease is not present care should be taken so that the transfer of the fungus from any source does not take place.

Certain farm practices such as plowing and cultivation to bury deeply the sclerotial bodies have been suggested by various workers. This suggestion is based on the fact that the fungous sclerotia, if buried about 10 to 15 centimeters deep in the soil, fails to germinate.

OTHER DISEASES OF COTTON IN THE COLLEGE OF AGRICULTURE

Leaf blight

A serious blight of cotton which threatened with premature death nearly all the plants of the variety Pima Egyptian occurred in the summer of 1935. There were over 200 plants of this variety in the multiplication field and in all of these most of the leaves were discolored reddish brown, and were uneven and scorched or dried along the margin. In light affection the trouble seemed to be confined to the lower mature leaves. In serious cases, however, entire plants were involved. It was noted in badly affected plants that all the leaves except a few immature ones were discolored from the margin inward. Owing to the death or weakening of the tissues at various places in the leaves and consequently cessation of growth in these areas the leaves curled and the surface became uneven. In general the plants were abnormally stunted in their growth. Although over three months old many of them were not beyond 30 centimeters tall. The less affected plants started to flower in April but these flowers either dropped off early without setting fruits or formed bolls which dropped off while young because of insufficient nourishment. Actual counts of the plants in the field showed that all of the variety Pima Egyptian were affected. The trouble, however, was confined to this variety. The native varieties of cotton, notably the Native Brown and Batangas White in the same field, were not affected.

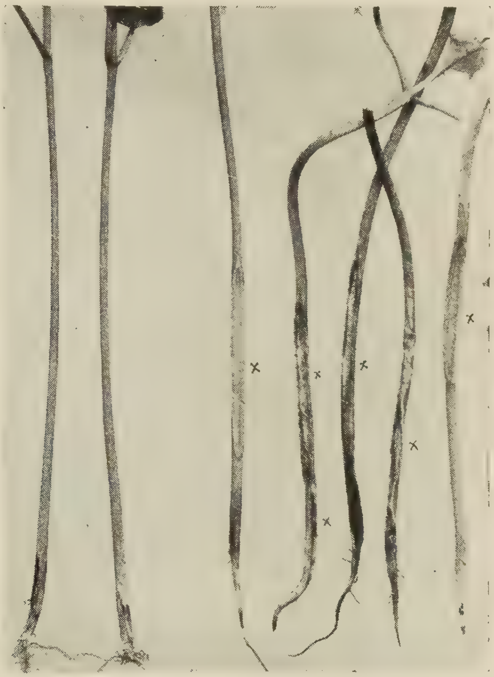

Fig. 3.—Young stems of cotton plants showing typical cracks (x). The two stems on the left are normal.

In order to determine the cause of the trouble, leaf sections were examined under the microscope. Some of the badly affected plants were uprooted and their roots sectioned and examined microscopically. These examinations of either the leaf or root sections did not show any organism in association with the tissues.

Early in April two of the diseased plants were potted and were kept in a partially shaded place where they were watered moderately from time to time. In three to four weeks these plants developed new shoots and formed green normal leaves. Early in June these plants produced flowers and formed a few normal bolls. Similarly, the plants in the field gradually recovered and attained normal growth after the rains in May and early in June. It appears from these results that drying or blighting of the cotton leaves in the field was occasioned by the heat in March and April. These plants were set out late in the year on account of several typhoons which occurred in the latter part of 1934. Consequently, the summer heat caught the plants early enough in their vegetative stage to cause a considerable scorching of their leaves.

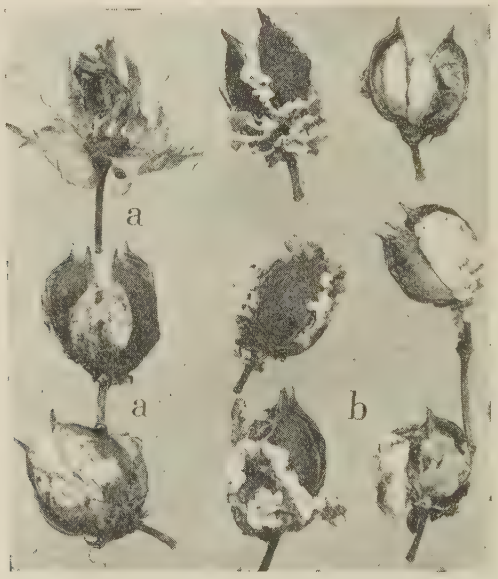

Fig. 4.—(*a*) Flower and cotton bolls affected with *Fusarium.* (*b*) Cotton bolls showing profuse development of *Schizophyllum commune* Fr.

Cracking or splitting of the stem

In the latter part of May and early in June, 1935 a peculiar cracking or longitudinal splitting of young cotton stems occurred in seed beds (fig. 3). The cracks often extended from the base of the stem to about eight to ten centimeters upwards exposing part of the interior region of the stem. The affected stem becomes so weak that it easily bent down or was slightly twisted around. Close examination of the mature cotton plants in cultures showed that the same trouble was present in several of the mature branches and leaf petioles. According to Dr. Eulalio P. Baltazar, this abnormal splitting of cotton stems has been repeatedly observed among young plants in culture in the Department of Agronomy.

The cause of the disease is not understood. Microscopic examination of the specimens did not reveal any fungus or bacterium associated with them.

Fusarium blight of flowers and boll rot

Blight or dry rot of flowers occurred among the cotton plants of the variety Batangas White in cultures in the Department of Plant Pathology. The disease is characterized by gradual rotting and drying out of the flowers. A diseased flower shrivel as it dries up and drops off often without setting any fruit (fig. 4a). If bolls are formed, while young they also become infected, shrivel and turn hard or mummified. Sometimes infection extends to the petioles and causes these to die and eventually fall off. On large sized bolls the fungus can be seen readily. Pale yellow masses of conidia appear on the surface, especially under humid conditions (fig. 4a).

Examination of diseased flowers and fruits revealed a certain species of *Fusarium* constantly associated with them. Although no definite proof is offered at present on the pathogenicity of the fungus its constant association with the host and the absence of other organisms suggest that it is probably the cause of the troubles. Studies are now underway to determine this more definitely.

Stem rot of seedlings

Stem rot of cotton seedlings repeatedly occur in seed beds. The disease girdles the stem at the base, close to the ground level or just below it. Two species of *Fusarium;* namely, *F. moniliforme* and *F. solani* var. *eumartii* and one species of *Rhizoctonia* were isolated from diseased stems on December 28 and 30, 1934. Studies are now in progress in the Department of Plant Pathology to determine the relation of these fungi to stem rot of cotton.

Anthracnose of cotton

Anthracnose is a serious disease of cotton. It attacks all varieties now grown in the College of Agriculture. A detailed account of this disease which is now nearing completion will be reported later.

Schizophullum commune Fries

Schizophyllum commune Fries was collected on cotton bolls on June 18 and 19, 1935. It grows well on the lock but not infrequently it also becomes associated with the lint and the seeds (fig. 4b). Infection is characterized, more or less, by dry rot. Affected bolls become hard or mummified with the fibers and the seeds converted into masses of dry and well-compact materials. When an infected boll opens, the fungus forces itself between the locks and develops aerially, producing conspicuous spore bearing bodies. *Schizophyllum commune* is found quite abundantly associated with dead branches and trunks of various trees shrubs and herbs. However, the relation of this fungus with these hosts, as in the nature of its association with diseased cotton bolls is not very well understood.

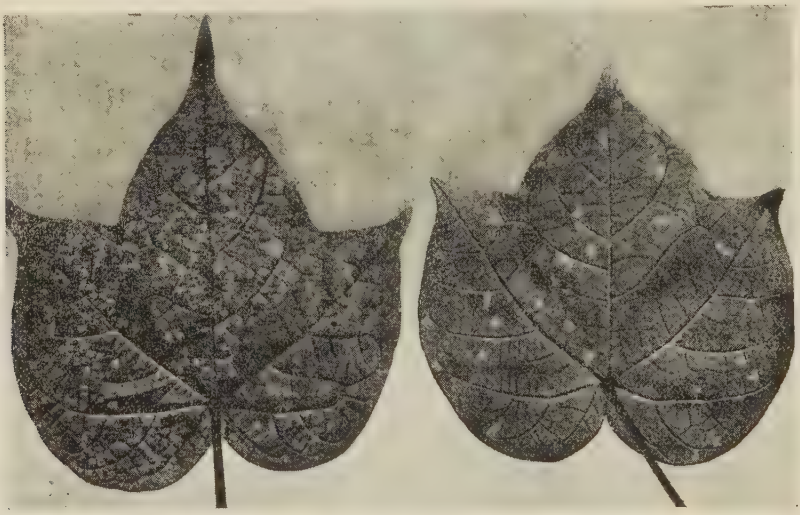

Fig. 5.—Nether surfaces of leaves of cotton, showing typical infection of aerolate mildew.

Areolate mildew

The disease has been noted in the cotton plants of the variety Batangas White in cultures of the Department of Plant Pathology on July 26, 1935. It is generally present on the nether surface but occasionally appears also on the upper surface of the leaves. The spots are white, turning yellowish to brown with age, vein limited, angular, measuring from 1–2 × 1.5–5 mm. and often with conspicuous "downiness" or frosty fungous growths on the surface (fig. 5).

These growths consists mainly of conidiophores and conidia. The conidiophores of the fungus are produced aërially, either singly, or in groups. They are hyaline occasionally septate and measure from 4.2–6 3 μ wide and from 37.8–86.1 μ long; average 4.4 × 57.46 μ. The conidia are hyaline, oblong, continuous to 3-septate, abruptly pointed at both ends, sometimes rounded, and are borne on the conidiophores either singly or in chain. They measure from 3–6.3 μ in width and from 16.8–33.6 μ in length; average 4.17 × 25.2 μ (fig. 6).

The causal organism is referred to as *Septocylindrium areola* (Atk.) P. and C. (= *Ramularia areola* Atk.),[2] a fungus not previously reported on cotton in the Philippines.

SUMMARY

1. This paper deals with *Sclerotium* and other diseases of cotton in the Philippines. Only the *Sclerotium* disease is dealt with at length in this paper.

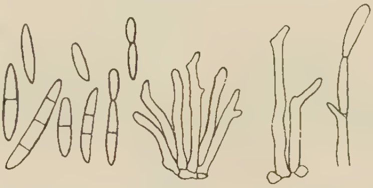

Fig. 6.—Conidia and conidiophores of *Septocylindrium areola* (Atk.) P. & C. (*Ramularia areola* Atk.), the cause of areolate mildew of cotton. Camera lucida drawings. Original figures about ×380.

2. The *Sclerotium* disease attacks cotton at the base of the stem close to the ground level or just below it. Seedlings and young cotton plants are especially susceptible to it.

3. The cause of the disease is similar to, if not identical with *Sclerotium rolfsii* Sacc., a fungus of world wide distribution and with not less than 40 different host plants in the Philippines.

4. This fungus grows best under humid or moist conditions.

5. The disease can be controlled in seed beds by soil sterilization. Heating the soil to 100°C. for 30 to 60 minutes render many of the sclerotial bodies harmless.

6. Suggestions for the control of the disease in the field consists of (*a*) preventing a locality from becoming infected with the dis-

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[2] Determined by Mr. E. F. Roldan, of the Department of Plant Pathology.

ease; and (*b*) eradication of the parasite from an infected field or locality by sanitary measures.

7. The results of studies on the other diseases of cotton which are now under way in the Department of Plant Pathology will be reported as parts of this series.

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TABLE 1

Showing the various host plants of Sclerotium rolfsii and the diseases it causes in the Philippines as reported by different investigators

INVESTIGATOR	YEAR	HOST PLANTS	DISEASES CAUSED
Reinking	1918	peanut (*Arachis hypogaea* Linn.)	stem rot, root rot
		coffee (*Coffea* spp.)	damping off
		citrus (*Citrus* spp.)	damping off
		beans (*Phaseolus* spp.)	blight
		rice (*Oryza sativa* Linn.)	stem rot
		seedlings of other plants	damping off
Wester	1920	mango (*Mangifera indica* Linn.)	damping off
Pereira	1922	rice	seedling stem rot
Ocfemia	1924	tomato (*Lycopersicum esculentum* Mill.)	fruit rot
		pepper (*Capsicum annuum* L.)	fruit rot
Ramos	1926	okra (*Abelmoschus esculentus* (Linn.) Moench.)	These plants were readily damped-off when inoculated with *Sclerotium rolfsii*
		casubha (*Carthamus tinctorius* Linn.)	
		patani (*Phaseolus lunatus* Linn.)	
		papaya (*Carica papaya* Linn.)	
		cockscomb (*Celosia cristata* Linn.)	
		mustard (*Brassica integrifolia* (West) O. E. Schulz)	
		pechay (*Brassica cornua* (Thumb.) Forbes and Hemsl.)	
		Stenolobium stans (Linn.) Seen.	
		Crotalaria anagyroides HBK.	
Atienza	1927	sitao (*Vigna sesquipedalis* Linn.)	
		poñgapong (*Amorphophallus campanulatus* Roxb.)	
		patola (*Luffa cylindrica* Roem.) (*Luffa acutangu'a* Roxb.)	
		Jerusalem artichokes (*Helianthus tuberosus* Linn.)	
		sugar cane (*Saccharum officinarum* L.)	
		avocado (*Persea americana* Mill.)	
		squash (*Cucurbita maxima* Duch.)	
		tomato	fruit rot
		pepper	fruit rot
Palo	1928	onion (*Allium cepa* Linn.)	bulb rot
de Mesa	1930	bagilumbang (*Alcuritis trisperma* Blanco) collected by Professor A. de Mesa in the nursery of the School of Forestry, Los Baños, Laguna, on September 15, 1930.	stem and cotyledon rot
Fajardo	1933	*Delphinium* sp.	stem rot
		carnation (*Dianthus* sp.)	stem rot
		amarylli lily	stem rot
		watsonia	stem rot
		petunia	stem rot
		Amazon lily (*Eucharis grandiflora* Planch. and Linden)	stem rot
		buñga de China (*Adonidia merrillii* (Becc.) Becc.	stem rot
Reyes	1934	peanut	wilt, stem rot
		rice	
		wheat (*Triticum vulgare* Vill.)	
		onion (*Allium cepa* Linn.)	
		buñga ng tubo (*Aeginetia indica* Linn.)	
		eggplant (*Solanum melongena* Linn.)	
		banana (*Musa sapientum* L.)	
		everlasting (*Helichrysum bracteatum* Willd.)	
Department of Plant Pathology, College of Agriculture		nangka (*Artocarpus integra* (Thunb.) Merr.)	
		ikmo or buyo (*Piper betle* Linn.)	
		lettuce (*Lactuca sativa* L.)	
		cacao (*Theobroma cacao* L.)	
		gabi (*Colocasia esculentum* (Linn.) Schott)	
		soybean (*Glycine max* (Linn.) Merr.)	
		abacá (*Musa textilis* Née)	
		dasheen (*Colocasia* sp.)	rot
		Christisonia sp.	
		indigo (*Indigofera hendecaphylla* Jacq.)	stem rot
		sweet potato (*Ipomoea batatas* (Linn.) Poir)	blight
		yautia (*Xanthosoma sagittifolium* Schott.)	rot
		corn (*Zea mays* Linn.)	stalk rot
		tobacco (*Nicotiana tabacum* Linn.)	damping off
		cutcharitas (*Alternanthera versicolor* Hort.)	stem rot
		cotton (*Gossypium* sp.)	

TABLE 2

Showing the effects of Sclerotium rolfsii, cotton strain, upon cotton and other plants

DATE OF INOCULATION	PLANTS INOCULATED	METHOD OF INOCULATION	PERIOD OF INCUBATION	SEVERITY OF INFECTION
1935			*days*	
March 25	Five cotton plants, 30-40 cm. tall	Fungus applied at the base of uninjured stems	5	All plants became infected. Only two died, the rest recovered from the disease
April 9	Cotton seeds	Seeds were planted in soil previously inoculated with *S. rolfsii*		More than 50 per cent of the seedlings that emerged from the soil became infected and later died
April 22	Ten mature or flowering cotton plants	Fungus applied at the base of the stems	5-6	Plants became infected under damp chamber conditions. All except one recovered from the disease in the field
April 22	Abacá, eggplant, lettuce, peanut, tomato, rice, soybean	Pure culture of *Sclerotium*, cotton strain, was applied at the base of the seedlings	5-6	All the inoculated seedlings died
April 22	Cotton seedlings	Strains of *Sclerotium* isolated from abacá eggplant lettuce, peanut, nangka, *Christisonia* soybean and indigo were applied separately on cotton seedlings	4-5	Every strain infected cotton seedlings readily

TABLE 3

Showing the seasonal occurrence of the Sclerotium disease in the Philippines

INVESTIGATOR	YEAR	MONTH	LOCALITY	CONDITIONS FAVORABLE FOR INFECTION
Reinking	1918		Laguna and other places in the Philippines	Wet weather
Wester	1920		Various places in the Philippines	Humid atmospheric condition or over watering in seed beds
Pereira	1922	July August September	College of Agriculture, Laguna	Moist soil favors the germination and growth of the sclerotial bodies
Ocfemia	1924	June	Laguna	After the rains in June
Atienza	1927	October November December	Laguna	Infection is common when the soil and air are always damp
Fajardo	1933	May	Trinidad Valley, Mountain Province	Favored by warm moist weather
Palo	1933	June July August September October November	Muntinlupa, Rizal	Especially prevalent in July and August when precipitation is rather heavy and when the mango seedlings are young and in their susceptible stage
Reyes	1933 1934	August	Ilocos Norte Pangasinan Batangas Laguna Rizal	Common and destructive during wet season
The writer		July	College of Agriculture and vicinity	The disease is occasionally virulent in the field under condition of humidity

SECULAR TRENDS OF LOCUST OUTBREAKS IN THE PHILIPPINES AND THEIR APPARENT RELATION WITH SUNSPOT CYCLES[1]

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WITH ONE MAP AND TWELVE CHARTS

Since 1572, when an anonymous author, probably one of the Augustinian priests who accompanied the Legaspi expedition, recorded a serious locust plague that lasted three years on the island of Panay, this insect pest has reared its destructive head intermittently through a long series of chronicles of the sixteenth and ensuing centuries. Notes sent by missionaries to their headquarters, documents left behind by government officials, articles and books prepared by foreign travellers, private correspondence, and, toward the concluding decade of the Spanish Régime, special treatises on various agricultural topics by Spanish agronomists have proved a most fruitful source of data on locust outbreaks. Even prior to Magellan, locusts had figured in Philippine folklore, as witness, for instance, the ancient legend of the Visayan goddess Lahon, who had to be kept humored lest she threw out from her abode in Mount Canlaon, on the island of Negros, fire and locusts to devastate the fields in the lowlands, indicating thus the great antiquity of the locust pest as a persistent menace to Philippine agriculture.

After American occupation, notable locust outbreaks, whenever they occurred, were invariably discussed in every annual report of the Philippine Commission to the United States Secretary of War, until the establishment of the Bureau of Agriculture (since 1930, Bureau of Plant Industry), when articles bearing on the locust situation began to appear, the earliest in 1909, from pens of the Bureau personnel. Quantitative data, however, as to the number of provinces and municipalities and, later, number of hectares infested were not collected until 1910. A convenient summary of the figures from 1912 to 1923 appeared in the chart facing page 26 of the Compilation of committee reports for the first annual convention of the

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[1] Experiment Station contribution No. 1131. Portions of this paper were read before the Los Baños Biological Club, March 26, 1936, and at the scientific conference, National Research Council, Manila, July 31, 1936.

Philippine Sugar Association (Atherton Lee, 1923) and from 1912 to 1931, in the chart facing page 260 of the annual report of the entomologist, Research Bureau, Philippine Sugar Association, Manila, 1930-1931 (Lopez, 1930-31).

For convenience in subsequent reference, as well as for the purpose of securing a unified 365-year perspective of locust outbreaks in the Philippines, and, likewise, to form a genetic picture of the succession of prevailing attitudes toward the locust problem, it was deemed justifiable to include in the present paper pertinent quotations, largely in English translation, from all historical sources available. These are arranged in chronological sequence. In the present compilation Blair and Robertson's indispensable set of historical documents, which appear, fully annotated and cross-indexed, in the fifty-five volumes of *The Philippine Islands* (1903-1909) have been freely used. Rev. Miguel Selga, S. J., director of the Weather Bureau, was kind enough to furnish a few of the references from otherwise inaccessible religious sources. No claim is made as to comprehensiveness. A great deal of the older literature is a mosaic of recitals of miracles, conversions, exploits of conquest, colonial problems, and allied subjects, with locusts entering casually here and there in the discussion, and it is easy enough to overlook significant passages. The writer will greatly appreciate whatever supplementary items readers may send him.

We have one unique advantage in the Philippines in that, although the older records were obviously written by persons who knew little or nothing about entomology, there can be no confusion as to the specific identity of the insect concerned. Where in such places as in African territories, for instance, the term "migratory locust" may mean one of at least three true migratory species, in the Philippines we have only one, namely the Oriental migratory locust, *Locusta migratoria manilensis* (Meyen), which we have in common with eastern China, Formosa, Malaya, Annam, north Borneo, and small Dutch-owned islands north of Celebes (Uvarov, 1936).[2] Migratory-locust swarms in Formosa are believed to originate in northern Luzon (Sonan, Inamura, and Shiraki, 1933); those in the Dutch East Indian islands, from Mindanao, as is also the infestation in Borneo (Uvarov, 1936).

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[2] Common and specific names and distribution furnished through the courtesy of Dr. B. P. Uvarov, Imperial Institute of Entomology, London, personal communication, November 18, 1935. These data are used with his permission. The same information appeared subsequently in revised form in Uvarov's (1936) published paper.

RECORDS OF LOCUST OUTBREAKS IN THE PHILIPPINES

1569-1572. Panay. An extremely great plague of locusts, which lasted three years, resulting in intense suffering among the people because of shortage of rice. "No field is sown which they do not destroy." (Anon., *Conquest of the island of Luzon.* Manila, April 20, 1572. Blair and Robertson 3: 152, 170).

1582-1584. All islands. "Three or four years ago, the pork, fowls, rice, and other produce of the country were sold very cheaply; now there is great scarcity (and has been for two years) of rice in the market. . . . . Many of the natives have died in the expedition to Maluco, Borneo, and elsewhere; and a plague of locusts has added to the distress in the islands." (Deposition of Juan Arze de Sardonel in "Annual income of the royal exchequer in the Philippines." Andres Cauchela et al. Manila, July 3, 1584. Blair and Robertson 6: p. 51–52, footnote).

Bataan, Luzon. "They also saw the land visited by a great plague of locusts, which attacked the field of the heathens but left those of the Christians untouched." (Aduarte, *Historia.* Blair and Robertson 30: 213-214).

1597-1598. All islands. Locusts devastating all islands for two years. . . . . "and our Lord received their [the people's] humble tokens of service and showed them that He was well pleased by turning aside the locusts from their crops and giving them that year very abundant harvests." (Chirino, *Relacion.* Blair and Robertson 13: 36, 38).

1599. Luzon. "In Cagayan valley, in the year 1599, there was a great outbreak of locusts which destroyed much rice planting despite the fact that many people were chasing them." (Aduarte, *Historia* 1, chap. 37; Malumbres, *Historia de Cagayan*, p. 33–34).

Chirino, in his *Relacion de las Islas Filipinas* (Blair and Robertson 13: 69–70), writes that in Manila in the latter part of June, 1599, "God had delivered their grain fields from the plague of locusts."

1604-1605. (?) Luzon. Villamor (1914, p. 14), citing no authority, records locusts on these dates.

1619. All islands. "It is feared that there will be much hunger in the islands during the present year, because the locusts are so numerous that they cover the fields and destroy the grains. May God help us!" (Anon. [A Jesuit priest]. *Relation of the events in the Philippine Islands and in neighboring provinces and reamls from July, 1618, to the present date in 1619;* Blair and Robertson 18: 227–228).

1631 (August). Cagayan, Luzon. "In the year 1631 there was another locust invasion of Cagayan Valley, the like of which they had never seen in their lifetime, covering the fields and the trees so that the ground could not be seen, resulting in the plantings seeming as if they were burnt. This happened in the month of August." (Aduarte 1: chap. 59; Malumbres, *Historia de Cagayan*, p. 34).

1633. Philippines. "During the reign of this governor [Don Juan Cerezo de Salamanca] the archipelago is afflicted by various calamities, such as bad crops, famine, epidemics, a plague of locusts, volcanic eruptions, and Moro piratical expeditions." (*Official Handbook of the Philippines*, Louisiana Purchase Exposition, 1904, p. 174).

1643. Mindanao (Iligan). "The land was scorched by drouth, which was general throughout the islands, from which ensued great losses. . . . . The drouth was followed by a plague of locusts, which destroyed the grain-fields; the father exercised them, and to the wonder of all, the locust thrust their heads into the ground, and the plague came to an end." (Murillo Velarde. 1749. *Historia de Filipinas.* Blair and Robertson 44: 68).

1643-1644. Mindanao. "This year there has been much famine among the Indians, because the rice harvest was a poor one, on account of the drouth, and because there came a multitude of locusts, which covered the fields. In less than half an hour they destroyed the grain in a legua where they settled down; and when they flew they formed so thick a mass that it seemed as if they would hide the sun. Never has the like plague been seen here." (Events in the Philippines, 1643-44 [sent from the Jesuit House at Manila]. Blair and Robertson 35: 84).

1645 (July). Cagayan, Luzon. "On July 17, 1645, locusts appeared in Malauog, Cagayan, in such adundance that there was not expected a single rice grain to eat. The people offered prayers to Santo Domingo in Soriano and they were freed from the pest." (Malumbres, *Historia de Cagayan*, p. 39).

1656. All islands. "Famine and misery in the islands as a result of a great plague of locusts." (*Official Handbook*, Louisiana Purchase Exposition, 1, 1904, p. 176).

1657-1658. All islands. "Great were the calamities suffered by the Filipinas Islands in the years 1657 and 58, which might have occasioned their entire ruin, if Divine Providence had not manifestly preserved them, at the expense of miracles and prodigies. . . . . This was followed by the plague of innumerable locusts, which, laying waste the fields, made general havoc, occasioning the famine which was the worst enemy of the poor. This was followed by its inseparable companion, pestilence, which made great ravages with a general epidemic of smallpox." (Diaz, *Conquistas*, p. 556; Blair and Robertson 41: 310).

1659. Cagayan, Luzon. "In 1659 locusts visited the valley twice. Cagayan suffered from the worst famine known." (Malumbres, *Historia de Cagagan* p. 39–40).

1668. Laguna, Luzon. "In 1668 the scarcity of food in Laguna was greatly accentuated by a large swarm of locusts which devoured all vegetation in their path, and a cavan of rice rose to the price of 24 reales." (Villamor, 1914, p. 15).

1687-1688. Manila and all islands. "This [influenza epidemic] caused a great lack of provisions in this and the following years, just as the locusts had occasioned like loss in the preceding year." (Diaz, *Conquistas*; Blair and Robertson 42: 268).

"To this local calamity [fire] at La [punta de la] Estacada [Chinese settlement in Manila, near Tondo and Bancusay] succeeded another affliction, which was general through the greater part of these islands; this was a plague of locusts, one of the worst which has been seen in them, for the locusts were so many that in dense and opaque clouds they darkened the sun, and covered the ground on which they settled. These insects ravaged the grain-fields, and left the meadows scorched; and even the trees and canebrakes they stripped of the green leaves. These locusts were so voracious that they not only laid waste every kind of herbage and verdure, but they entered the houses, and gnawed and pierced with holes every kind of cloth; and those who flapped sheets and coverlets at the locusts to drive them away—as is usually done at other times in the invasions of this pest, with some effect—on this occasion found that the only result was to ruin those articles, for the locusts ate them, and destroyed them with their poisonous jaws. Thereupon the people began to feel the loss which ensued from this calamity, in the great scarcity and want of provisions—so great that a cabán of rice (which is half a fanega) came to be worth two pesos and a half, and in some places three pesos." (Diaz, *Conquistas;* Blair and Robertson 42: 261–262)

"They had another dish [in Bashee or Bachi Islands, Batanes] made of a sort of Locusts, whose Bodies were about an Inch and one half long, and as thick as the top of one's little Finger; with large thin Wings, and long and small Legs. At this time of the year these Creatures came in great Swarms to devour their Potato-leaves and other Herbs; and the Natives would go out with small Nets and take a small Quart at one Sweep. When they had enough, they would carry them home, and Parch them over the Fire in an earthen Pan; and their Wings and Legs would fall off, and their Heads and Backs would turn red like boil'd Shrimps, being before brownish. Their Bodies being full, would eat very moist, their Heads would crackle in one's Teeth. I did eat once of this Dish, and liked it well enough." (Dampier, *A new voyage round the world;* Blair and Robertson 39: 103).

"In the following year [1688] the scarcity of food [in Manila] was increased by a plague of locusts, which swept away all [vegetation]; and a cabán of rice came to be worth twenty and twenty-four reals." (Murillo Velarde, fol. 345b, 346; Blair and Robertson 39: 147 [footnote]).

1717-1718. All islands. "(Nor has the poverty been less which is being experienced while I am writing this, on account of the great plague of locusts which occurred in the past year of 1717 and the present one.)" (Diaz, *Conquistas;* Blair and Robertson 42: 262).

"Around 1718, shortly after this town [Orani, Bataan] became a vicarage, the island of Luzon was sadly stricken by a frightful plague of locusts. The Indians saw from all directions these dark clouds that hid the midday sun, shortly reducing the place into desolate wastes. Only the inhabitants of Bataan felt secure in the face of this great calamity, because of their faith in the protection that the heavenly patron saint in Orani is wont to give them. The vicar of that town, Fr. Diego de Liano, solicitous of the welfare of his flock, exhorted the people to attempt the destruction of the locusts by means of the methods commonly known and used in these islands. They, however, inspired by an intense faith in the Virgin of the Rosary, answered him in ardent belief: 'Father, we need make no further effort than pray to our Mother and trust Her, because we are sure that through Her intercession not even a blade of rice will be damaged.' It happened, in effect, promptly as the Indians expected; because the locusts, as if driven by a hurricane, hastened to the seacoast without causing the least injury to the crops of that town." (*La Virgen María Venerada en Sus Imágenes de Filipinas*, p. 77).

1731. Cagayan, Luzon. "A chronicle written in 1737 by the Dominican Father Francisco Rojano states that in 1731 the inhabitants of Abulug, Cagayan, held a big religious procession against locusts, in which they carried many holy images which they deposited in a *camarin*." (Malumbres, *Historia de Cagayan*, p. 363).

1732-1736. All islands. "There were other invasions of locusts which are mentioned by Father Chirino up to the year 1736. So great must have been the damages caused by this plague that in 1732 the former 'Ayuntamiento de Manila' offered to proclaim Saint Augustine as its patron against locusts." (Villamor, 1914, p. 15).

1818. Philippines. "It [the country] is seldom, if ever, afflicted with drought, but is at times devastated by locusts (perhaps once in 10 or 15 years), and there make dreadful havoc among the canes. Their attacks, however, are partial, and generally take place after the rice is harvested in December, disappearing before the rains. In 1818, nearly the whole of the canes were destroyed by them, and the Ayuntamiento of Manila expended from 60 to 80,000 dollars in purchasing large quantities of them, which were thrown into the sea." (*Remarks on the Philippine Islands and on their capital Manila 1819 to 1822.* By an Englishman. Calcutta: Baptist Mission Press. Blair and Robertson 51: 126–127).

1854 (October). Visayas. "In October, 1854, swarms of locusts invaded the province of Iloilo and the politico-military commandery of Bohol." (Villamor, 1914, p. 15).

1860. Leyte. "In the afternoon of the day after my arrival at Tacloban, on a sudden there came a sound like the rush of a fearful torrent; the air became dark, and a large cloud of locusts swept over the place." (Jagor, *Travels in the Philippines*, ed. Austin Craig. 1917, p. 260).

1862. All islands. "During this administration [of Don Rafael Echague, governor of the Philippines, 1862-1865] the Archipelago is afflicted by cholera, fire, flood, cyclones and locusts." (*Official Handbook*, Louisiana Purchase Exposition, 1904, p. 184).

1879 (about June). Laguna, Luzon. "About June, 1879, the province of Laguna was also invaded by locusts." (Villamor, 1914, p. 15).

1886 (August). Laguna and Batangas, Luzon. "Calamba, August 27, 1886. Whole towns, such as Calamba, Santo Tomas and Tanauan, are covered with hoppers, a pest which destroys all kinds of crops." ([Rizal Mercado], Paciano. *In* Kalaw, 1930, p. 185).

[In Tagalog]. "Calamba, August 29, 1886. From July to the present, there has been no market for sugar; likewise, since June, the whole town is covered with flyers and hoppers that are seriously damaging the rice and cane, which affliction, among others, is greatly felt here. The Governor donated ₱50 to pay the men catching hoppers and although the price is very low at the Tribunal, being ₱0.125 (*saicapat*) a cavan and a half, the number of hoppers does not seem to decrease. Residents here estimate that to date three hundred cavans of hoppers have been caught in this town alone. A great deal more is left and, although the money donated by the Governor is already exhausted, the people continue catching and do not stop." (Hervosa, Mariano, *In* Kalaw, 1930, p. 187–188).

1886 (October 17). "This is the only thing [riddance from bandits] that this town [Lipa] should expect, because, in spite of invasion by locusts, which destroyed the rice crop, business continues and we will harvest coffee, which is the principal resource of this town and to which it owes its progress." (Reyes, Felipe; quoted by Retana, 1893).

1895 (June). Luzon. "During the first days of June of the past year, several provinces of north and central Luzon were invaded by locusts. This pest had its origin in the mountainous districts of Cagayan province in its boundary with Ilocos Norte, spreading thence to both Ilocos, Abra, La Union, Zambales, Pangasinan, Tarlac, Bulacan, Pampanga, Batangas, and Tayabas, causing, fortunately, little damage to crops and resulting in negligible reduction in harvest." (Bores, 1896).

Alcarraz (1895) gives results on field surveys, with biological notes, on migratory locusts in the Ilocos provinces.

1902-1903. Luzon, Visayas and Mindanao. "The plague of locusts in 23 of the provinces during the last year has been more severe than usual, the only provinces unaffected thus far being Bataan, Benguet, Bohol, Cebu, Masbate, Paraguas, and Sorsogon," (Report of the Civil Governor for the period ending December 23, 1903, p. 689). Also in the Fourth Annual Report, Philippine Commission (1903), p. 567: "Very heavy losses have been inflicted upon agriculturists during the past year by the depredations of enormous swarms of locusts." [Act No. 817, Philippine Commission, creating provincial locust boards, passed August 3, 1903].

1903 (October) – 1904. Luzon and Visayas. "Although some of the provinces have suffered severely in this regard since October 1, 1903, to the date of this report in the nineteen provinces to which the plague seems to have been limited, [the amount of locusts caught] was 11,242,547 pounds, or 5,621.27 tons, as against 8,501⅝ tons last year. The greatest sufferers in this respect during the present year have been Albay, Pampanga, Tayabas, Batangas, and Occidental Negros." (Fifth Annual Rpt. Philippine Commission, 1904, pt. 1, p. 318).

1905. Luzon and Visayas. "Only 25 per cent of the provinces were affected by the locust plague during the period covered by the present report. . . . . reports from the provinces showed a decided falling off in the damage done by it." The report then enumerates the number of pounds of locusts destroyed in the provinces of Bohol, Bulacan, Capiz, Ilocos Norte, Laguna, Leyte, Masbate, Nueva Ecija, Pampanga, and Tayabas. (Sixth Annual Rpt. Philippine Commission, 1905, pt. 1 [Fourth Annual Rpt. Executive Secretary to Governor General for year ending September 30, 1905] p. 94).

1909. Central Luzon and Visayas. "The provinces afflicted [June] are Bataan, Batangas, Bulacan, Capiz (including the subprovince of Romblon), Cavite, Cebu, Iloilo, Occidental Negros, Oriental Negros, Pampanga, and Rizal." (Hobart, 1909).

1910. Central Luzon and Visayas. "During the past season [published in April, 1910] reports were received most persistently from Negros and central Luzon, although locusts were known to be present in Cebu, Leyte, Panay, and other islands." (Mackie, 1910).

"Locusts were prevalent in a number of localities during the months of August and September, due largely to the prevailing drought which was favorable to them." (Nesom, 1911).

1910 (November). [In the monthly crop reports for November, 1910 (Phil. Agric. Rev. 4: 40. 1911), reports of poor crops due to typhoon, rats, and poor soil conditions have been recorded but none due to locusts, except slightly in Bohol.]

"It was not until 1910 that any active campaign was waged against locusts. . . .

"The reports received have been of great value; from them we have been able to ascertain the number of provinces invaded, the areas of greatest infestation, the apparent movements of invading swarms. . . .

"Reports show the area of greatest infestation to be a broad belt extending from Romblon to Bohol and including Romblon, Antique, Iloilo, Capiz, Occidental Negros, Oriental Negros, southern Cebu, and Bohol, and the flying swarms to be moving in a northeasterly direction travelling with the southwest monsoon." (Mackie, 1911).

1912. Southern islands, especially. "At the end of the long dry season great swarms of locusts appeared, especially in the southern islands." (Rpt. Philippine Commission 1912, p. 25. [Rpt. of the Governor General]).

"An outbreak in Cebu was the worst single attack reported for several years. The swarm covered about 15 square kilometers of territory and swept practically across the island. . . . During the year outbreaks were reported in 15 provinces. With few exceptions they were promptly controlled." (Rpt. Philippine Commission 1912, p. 243 [Rpt. of the Secretary of Public Instruction]).

"In May of the present year [1912] the northern invasion began (Luzon provinces). Swarms developed in the uncultivated lands of northern Tayabas and Isabela, migrated west, and virtually overran the provinces of Nueva Ecija, Nueva Vizcaya, Bulacan, Rizal, Laguna, and Tayabas. From these provinces, the provinces of Tarlac, Pangasinan, Pampanga, Bataan, Cavite, and Batangas were invaded.

"The influence of the drought upon the increase of this pest is shown by reports of locust infestation from 30 provinces the year following the drought, as compared with but 7 reports of invasion received the year before." (Mackie, 1913).

1913. All islands. "By June 1 practically all the provinces of central and southern Luzon, with the exception of Zambales, had been invaded by flying swarms and at the close of the year not only these provinces but practically all others (33 out of 38) were infested more or less with one or more species of locusts. In some provinces, such as Tarlac, Nueva Ecija and Rizal, the infestation is so widespread that it must necessarily be a question of months, if not years, before the uncultivated cogonales are completely cleared of the breeding swarms which, although quite exterminated in the cultivated areas, persist in these back districts and resist all regular methods of control." (Edwards, 1913).

1914-1915. All islands. "For a number of years the Philippine Islands have been infested with enormous swarms of locusts, nearly every province having suffered from this pest . . . During the year 1915, thirty different provinces were furnished allotment of funds and equipment for fighting locusts in a total amount of ₱49,112." (Edwards, 1916).

1916. All islands. "Due to the transfer of inspectors to other divisions and the fact that the general elections were on, it became impossible to give the locust campaign the attention it merited. As a result, the infestation increased and from April 15 to July 15 it had spread from 35 to 114 towns, an increase of 79 towns, or over 300 per cent. The greatest increase was between May 20 and June 20, when the infestation increased in 30 days from 47 to 107 towns. About the middle of July, inspectors were detailed and an organization was effected which brought the number of infested towns from 114 on July 15 down to 35 on October 15 . . . Noteworthy among the results accomplished by the provinces is that rendered in the non-Christian districts of the Mountain Province, especially in Kalinga and Ifugao. This is also true of Pangasinan, Tarlac, and Nueva Ecija . . . At present all inspectors are concentrated in the district comprising the areas along the Tarlac-Nueva Ecija-Pangasinan boundary where a heavy infestation occurred in November." (Mackie, 1917).

1917. "It is with pleasure that it can be announced that the Islands are now free from the grip of locusts. It may be safely said that during the present year, there has been no damage to agricultural crops by this pest. On July 28, 1917, no known locust swarms existed in the Archipelago, a statement that could be made for the first time since the earliest settlement of the Islands." (Hernandez, 1919a).

1918. "During the fiscal year [1918] locust infestation was at a very low point, having been reported from a relatively few provinces and then only in a mild form." (Hernandez, 1919b).

"The following year [1918], however, locusts in great numbers appeared in Bukidnon, Cotabato, Davao, Sorsogon, Nueva Ecija and Pangasinan." (Gonzales, 1932).

1919. "The infestations during the year under consideration [1919], although exceeding those of 1917 and 1918, have nevertheless been mostly confined to the Department of Mindanao and Sulu and very little damage has resulted . . . Mindanao has had the best of harvests. This is in a measure due to our prompt sending of inspectors, the quick organization of campaigns and providing of funds. In many cases, the locusts have been checked in record time." (Hernandez, 1920).

1921. "Locust infestation this year has gradually increased from 20 towns during March to 90 towns between the middle of July and August, 1921, and by the end of the year there were 58 towns infested." (Hernandez, 1922).

1922. "The locust infestation increased from 60 to 381 infested municipalities for the month of July but went down again to 70 at the close of the year." (Hernandez, 1923).

"The most serious infestation during the season (1921-1922) occurred in the provinces of Batangas, Laguna, Cavite, and Rizal, with little or no infestation in Bulacan, Pampanga, Tarlac or Pangasinan . . . . Negros was also infested during the 1921-22 season lasting from May until October." (Atherton Lee et al. 1923).

1923. "In this year the provinces south of Manila on Luzon were but slightly infested, the more serious infestations being in Mindoro, Bulacan, Pampanga, Nueva Ecija, Tarlac, and Pangasinan, with a rather serious scare in Negros . . . . In Negros heavy infestations were reported flying from Guimaras in the month of June." (Atherton Lee et al., 1923).

1924-1925. "The locust infestation during 1925 was less serious than usual, at the beginning of the year there being but 45 towns infested, as compared with 50 in 1924 . . . . The maximum number of towns infested was 121, while in 1924 it was 208.

"The three most seriously infested provinces were:

"1. Tabuk and the provincial district of Kalinga, Mountain Province . . . The swarms in Cagayan and Isabela probably came from there.

"2. The region on either side of the mountains in the Bondoc Peninsula, which is grassy but sparsely settled.

"d. The province of Bohol, which is continuously infested because of the central plateau, where there are dense cogonales whence locusts swarm not only the rest of the island but also over the surrounding provinces of Leyte, Cebu, Oriental Negros, and Misamis." (Youngberg, 1926).

1927. "Locust scouting was pushed energetically during the first nine months of the year, especially to free Bohol and Mindoro, which have been infested for the last five years and are the source of infestation for the Visayas and Luzon. They were finally cleaned up about the end of April and May, respectively." (Youngberg, 1928).

1928. "Infestation at the close of the year was much lower in 1928 than in 1927. [Comparative figures given]. In previous years locusts infested continuously several provinces of the Visayas, but this year they were entirely free, except in the earlier months when Oriental Negros was yet infested with the remnants of 1927. The campaign succeeded in keeping the pest in the interior of northern Luzon and mostly in places without standing crops. . . . . The airplane which was flown to the Cagayan Valley on June 29, 1928, scouted an area of approximately 90,000 hectares and dusted about 63 hectares." (Youngberg, 1929).

1929. "But on September 12, 1929, Tawit in the Mountain Province—the only place reported infested—was freed." (Gonzales, 1932).

1930. "Localized locust outbreaks were reported from Mindoro, Occidental Negros, and Isabela. These were promptly attended to and the insects destroyed before any appreciable damage to crops was done." (Roxas, 1931).

"There were three provinces infested by locusts in 1930; namely, Davao, Mindoro, and Occidental Negros. These infestations, however, were not alarming and they were promptly stamped out under the direction of the field men of the Bureau of Plant Industry in coöperation with the municipal officials." (Otanes, 1932).

1931. "During the year, 31 municipalities, in 11 provinces were slightly infested with locusts, though no serious damage was reported. . . . . The first province reported infested was Iloilo and the last was Cotabato, where there was still one municipality infested at the close of the year." (Roxas, 1932). On p. 154, table shows infestation in the following provinces: Iloilo (June 11-September 2), Capiz (June 11-July 14), Occidental Negros (July 16-July 21; August 3-October 3), Leyte (July 29-August 5), Batangas (August 4-29), Tarlac (August 5-15), Samar (August 7-10), Cebu (August 12-October 17), Masbate (August 20-September 5), Cotabato (August 29-December 31).

1932. "Early in 1932 migratory swarms broke out in Cotabato, infesting the municipalities of Buayan, Koronadal, Buluan, and Liguasan. Proper precautions were taken to stop their further spread but to no avail. The infestation soon spread to Davao. About the end of March, Lanao was infested and during the month of April the infestation spread to Zamboanga, Oriental Negros, Occidental Misamis, Agusan, Oriental Misamis, Palawan, Iloilo, Surigao, Bukidnon, Occidental Negros and Antique. In May, infestation spread further to Cebu, Bohol, Leyte, Samar, Masbate, and Romblon. In June Capiz was infested. Slight infestations also occurred in Tarlac, Nueva Ecija and Marinduque but they were promptly controlled. Altogether there were twenty-four provinces infested with locusts in 1932. . . . . Of the 350 municipalities infested during the year, 170 were completely cleaned up." (Roxas, 1933).

1933. "With the reorganization and the marked improvement in the locust situation these [entomological research] workers can now resume their work, particularly on the studies of pests that are just as destructive as locusts. . . . . Along with the campaigns in the provinces, observations and tests were made on the control of the migratory locust, particularly with the use of poisoned bait. As stated elsewhere, rice chaff and bagasse were found to give better results than ordinary rice bran. . . . . On the whole, the locust control work has been made more scientific, effective, and economical with the use of bait and dust. This may be considered as one of the outstanding achievements of this Bureau." (Rodriguez, 1934).

1934. "Locust has been the most serious pest during the year. . . . . A total of 174 municipalities in 22 provinces were infested during the year [table 1: Leyte 23, Cebu 17, Capiz 17, Samar 14, Albay 11, Cotabato 11, Misamis Oriental 11, Bukidnon 9, Masbate 8, Camarines Sur 7, Iloilo 7, Romblon 7, Lanao 6, Sorsogon 5, Surigao 4, Bohol 4, Agusan 3, Mindoro 3, Tayabas 3, Marinduque 2, Camarines Norte 1, Davao 1].

"The locust pest in 1934 destroyed 2507 hectares of palay, 3762 hectares of corn, 1511 hectares of sugar cane, 77 hectares of miscellaneous crops and defoliated 43,199 coconut trees. The destruction would have been much greater were it not for the relentless fight waged against the pest in which 511 cavans of locust eggs, 90,984 cavans of hoppers, and 31,333 cavans of fliers were destroyed.

"At the beginning of 1934, the area infested by locust was 421 hectares in 42 municipalities. By the latter part of October, the infested area had increased to 5,964 hectares in 67 municipalities as new infestations appeared in the isolated areas of Cotabato. As a result, however, of the relentless fight against the pest, by the end of 1934, only 701 hectares in 43 municipalities remained infested, the rest having been freed." (Camus, 1935).

INTERVALS OF OUTBREAK CYCLES

The "an Englishman" who was in the Philippines from 1819 to 1822 (Blair and Robertson 52: 126-127) was apparently the first to record, evidently from information furnished by local residents, the fair degree of secular regularity in the occurrence of locust outbreaks. He stated, as quoted above, that locust swarms appeared, presumably in and near Manila, "perhaps once in 10 or 15 years." It will be seen from the sequence of dates appearing in the foregoing historical compilation that from the earliest recorded locust outbreak, in 1569, to the present the intervals are surprisingly close to these figures. Table 1 shows that the range is from 7 to 15 years. The mean duration of each locust cycle, giving allowance for long intervals between records in which data are obviously missing, is 11 years.

In a sense, despite absence of quantitative data which would lend themselves to treatment by currently accepted statistical methods, the nineteenth-century and earlier records give in bolder relief a picture of the periodic trend of locust outbreaks in the Philippines than those of the present century. Mindanao and certain other southern Philippine localities, we know from recent unpublished findings to provide ecological conditions most favorable to maintenance of permanent reservations for migratory swarms. Since American occupation, these places have become virtually a next-door neighbor, thanks to modern methods of communication, so that, as will be seen in chart 2, if numerical fluctuations be not considered, there would hardly be a year that was not a locust year in the Philippines. As a matter of fact, this very conclusion, which would tend to deny the existence of a locust periodicity in the Philippines, has been arrived at by Lopez (1930-31). Goseco (1933) subscribed to practically the same idea in a somewhat modified form, which was reminiscent of an older observation of Delgado (1892), who wrote, "The locusts are almost a continuous plague in one place or another in this Archipelago."

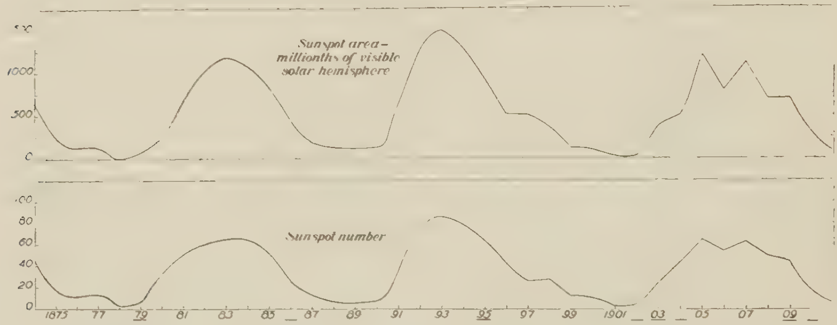


Chart 1.—Sunspot area and sunspot number, 1874 to 1910 (observed data). Known locust outbreaks in underscored years.

Sir John Bowring (1859) gives us some vivid glimpses into conditions in the Spanish times when he notes that "the voyage from Manila to Jolo and return occupies seven to eight months" and that "the post-office establishments are imperfect and unsatisfactory and the charges for the conveyance of letters heavy. There is a weekly postal communication from the capital with the provinces in the island of Luzon, and southwards as far as Samar and Leyte, but all the other eastern and southern islands are left to the chances which the coasting trade offers and are frequently many months without receiving any news from the capital or the mother country [Spain]. A regular service for the wants of these important districts, Panay especially, with its population exceeding half a million, is greatly to be desired." In addition, it must be remembered that telegraph lines existed in Luzon only, and then not before 1873. Hence, the

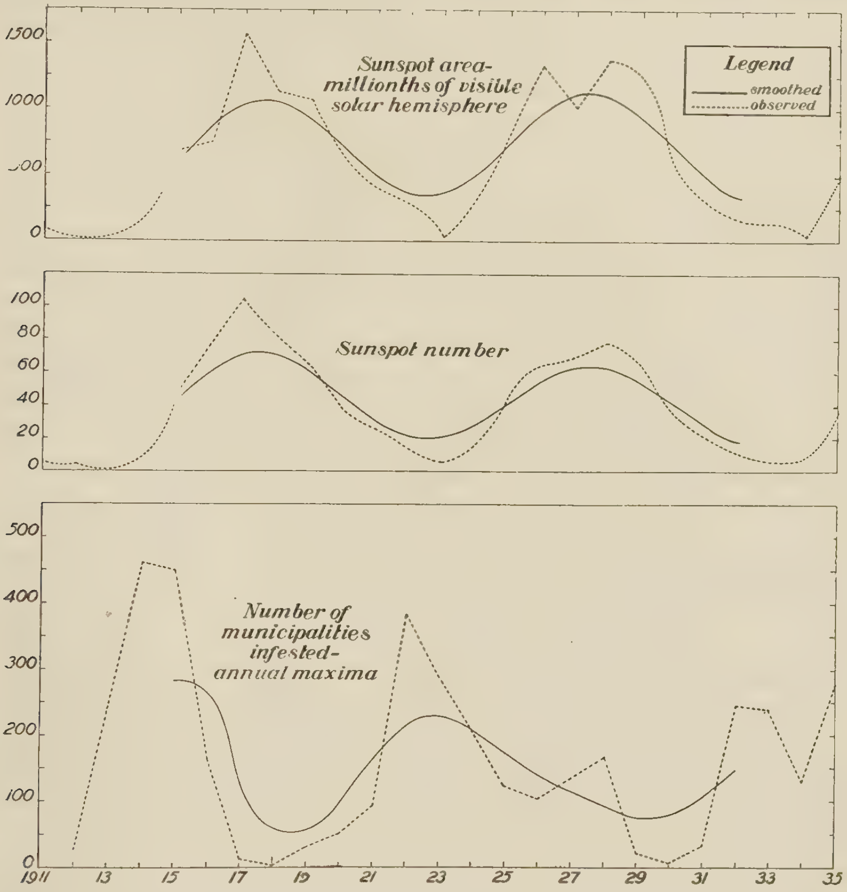


Chart 2.—Sunspot area, sunspot number, and annual maximum number of municipalities infested by locusts, 1911 to 1935.

larger bulk of the Spanish records dealt exclusively with Manila and neighboring localities where, as will be shown in another paper by the writer, locusts apparently occur only in really bad locust years or in what probably corresponds to the peak of locust intensity in the Archipelago. This regional limitation can be secured from contemporary data at the expense of laborious sifting of the required items from published total summary figures and from the typewritten file sheets of the weekly locust reports of the Bureau of Plant Industry, of which the writer could get access only to copies dating from August 29, 1934.

CORRELATION BETWEEN SUNSPOT CYCLES AND LOCUST OUTBREAKS

The literature bearing on the relationship between solar and terrestrial phenomena has grown rather voluminous. More or less successful attempts have been made to establish the relation of sunspot fluctuations with changing levels of certain lakes, droughts, floods, earthquakes, volcanic eruptions, oscillation in the number of wild ducks, rabbits, and other games, prosperity or business depression, crop yields, famine, insect pests, and a number of other earthly events. A fascinating popular article on this subject, by E. V. Wilcox, appears in the *Country Gentleman* for August, 1934.

Uvarov (1931, p. 158-160) gives an illuminating review of the literature on periodicity of insect outbreaks in various countries in Europe and in America. His contention is that "the fact that fluctuations in the number of certain insects coincide to some extent with the 11-year sunspot period can scarcely be disputed" and that many of the causes of failure to establish correlation are due (a) to the assumption that different species respond in the same way and (b), in the case of locusts, indiscriminate consideration of different species occurring in diverse climatic areas. Neither objection would, of course, hold in the Philippines, where we are dealing with only one form.

In the present paper, two sets of sunspot data are used: (a) Fritz and Wolfer's sunspot relative numbers, of which the figures from 1750 to 1924 were obtained from Sir Napier Shaw's (1928) compilation and those for later years from the leaflets issued by the International Astronomical Union, Zurich. (b) Sunspot area in millionths of visible solar hemisphere, the data for which from 1875 to 1932 were obtained from the compilation of Garcia-Mata and Shaffner (1934) and those for later years from the *Monthly Notices of the Royal Astronomical Society* (London) as well as from the

Monthly Weather Review (Washington). It is, of course, conceded that the data on sunspot area, the London reports on which are based on observations in the Greenwich and Kodaikanal Observatories and the Washington reports, on those in the Naval Observatory, in coöperation with Harvard, Yerkes, and Mount Wilson observatories, give more accurate figures because they represent results of actual measurements. The relative sunspot numbers, on the other hand, have in part been determined by means of a formula, and not by actual observation. However, the two series of data are used side by side in the present work both for the purpose of mutual check and also because figures on relative numbers extend back over many more years. Likewise, if eventually forecasting locust outbreaks be attempted with the aid of these criteria, data on sunspot relative numbers are somewhat more promptly available than those on sunspot area.

The data on locusts from 1912 to 1931 were based on compilations of the Philippine Sugar Association from figures furnished by the Bureau of Agriculture and its successor, the Bureau of Plant Industry. The data for later years were obtained directly from the Bureau of Plant Industry. For purposes of correlation, the highest single total number of municipalities infested during the year, in whatever month it occurred, rather than the average or cumulative total for the year, was taken as the figure for that year. The former is more indicative of the degree of annual intensity because the shorter cycles of seasonal fluctuations are disregarded and, likewise, duplicate entries of the same municipalities are avoided. At best, of course, these figures possess one inherent weakness in that municipalities as units of measure are extremely variable in size, topography and other peculiarities of local conditions, distribution over a given area, etc.; but until a more precise, workable quantitative method can be developed and used, we shall have to rest content with this only alternative. There is, however, one redeeming feature in that, owing to the sparser population in the almost perennially locust-infested provinces in such islands as Mindanao, a given area evaluated in numbers of municipalities there would appear at a discounted figure, compared with other areas of corresponding size on more populous islands where locust periodicity is more marked. Hence, an automatic natural "weighting" of the data results.

In charts 1 and 2, sunspot areas, sunspot relative numbers, and locust infestation are plotted in curve-parallels. Locust outbreaks prior to 1912 are indicated by underscoring the year in chart 1, with no attempt at quantitative expression. The observed data in chart

2 are smoothed according to the method suggested by Macaulay (1931) and modified by Garcia-Mata and Shaffner (1934) in their paper on business cycles. The formula is

$$x = \frac{a + 3b + 5c + 6d + 5e + 3f + g}{24}$$

the result of which is "a weighted moving average of seven terms whose 'graduation weight diagram' shows a smooth curve roughly comparable with the ones of Macaulay." As pointed out by Garcia-Mata and Shaffner, "from a practical point of view this method has the advantage that it can be used by taking a 4-year moving average of a 3-year moving average of a 2-year moving average, and this is very important in an investigation like the present one in which so many curves must be tested."

Considering the crudity of the figures on locusts, the smoothed results appearing in chart 2 show a most surprising relationship in the inverse course that locust infestation takes with respect to sunspot fluctuation. Likewise, the coefficient of correlation between observed sunspot area in millionths of visible solar hemisphere and observed number of municipalities infested from 1912 to 1935 (twenty-four years) is –0.44 ± 0.111, which indicates an admissibly decided negative correlation.

An examination of charts 1 and 2 shows that in general widespread locust outbreaks in the Philippines occur in years in which the annual average sunspot area is 500 millionths of the visible solar hemisphere, or less. Years in which the sunspot areas are above 500 are relatively locust-free. It may, likewise, be inferred from the sequence of events in the records that what few outbreaks occur during years of sunspot high are largely confined to Mindanao and islands in the immediate neighborhood. Locust swarms appearing in the higher latitudes, such as northern Luzon, during those years apparently represent straggling remnants of a dying outbreak cycle.

The damped undulation of the smoothed curve for number of municipalities infested by locusts in chart 2, which presumably represents an amplified inverse effect of solar fluctuations, suggests that these cycles are probably harmonic components of a major astronomical cycle. In addition to the 11-year sunspot period, Clough (1933) proves the existence of longer periods of 37 years (Brückner's cycle), 83 years, and 300 years, and correlates these with such terrestrial phenomena as frequency of auroras, severe winters, Chinese earthquakes, low stages of the Nile, and Sequoia growth rings. He, moreover, notes a long period of 1400 years.

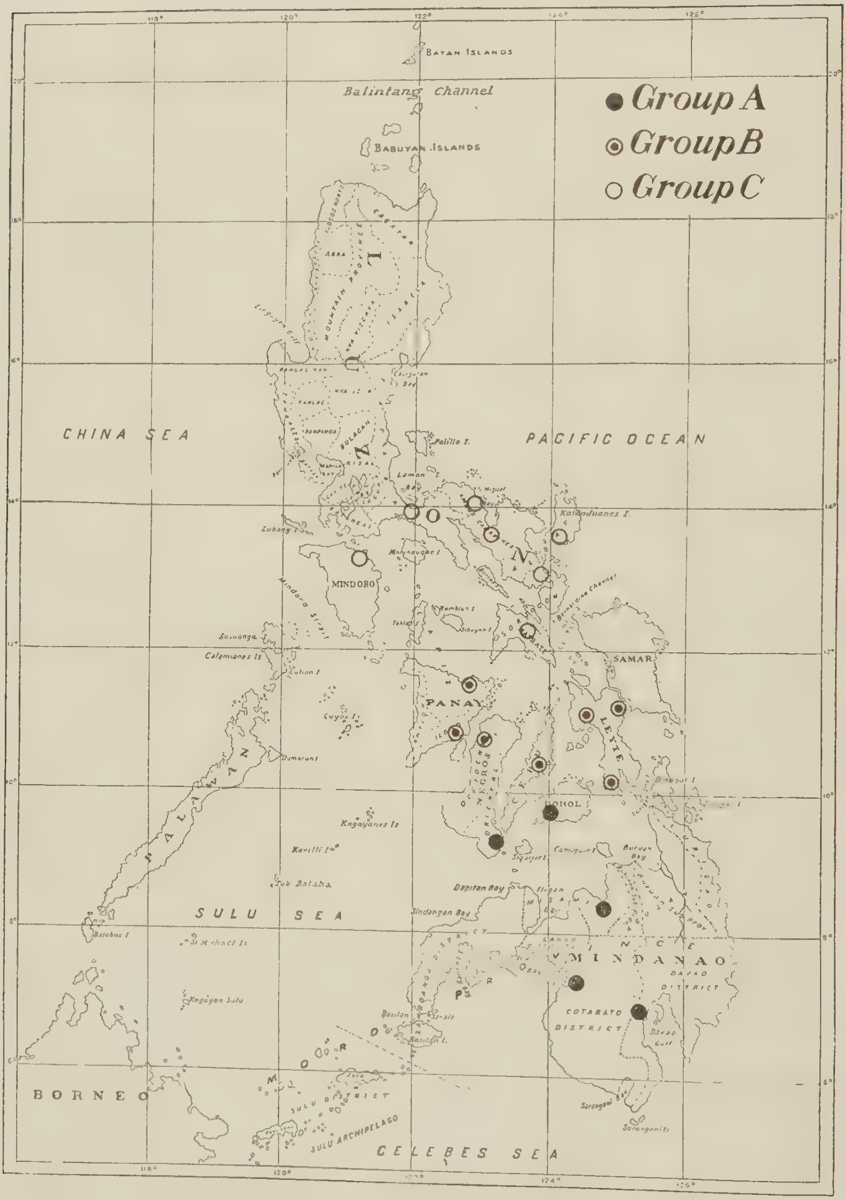
SUNSPOTS, CLIMATIC FEATURES, AND LOCUSTS

Among the various environmental factors, climate is known to exert an important, if not the dominant, influence in the production of the gregarious phase in locusts. Predtetchenskii (1925), for instance, finds that in *Locusta migratoria rossica* Uvarov et Zolotarevsky in Central Russia conditions favorable for development are brought about by years of warm dry summers and short cold winters; cool moist summers delay metamorphosis; long warm autumns encourage egg mortality from fungi; and thus a swarming phase reaches its climax in the year following two years of drought. After a critical year and as a result of scattering of the swarms, there is then a transformation into solitary or non-migratory phase.

Random observations, as noted in three of the historical excerpts reproduced in the present paper, namely Murillo Velarde (1643) in Mindanao, Nesom (1911), and Mackie (1913) tend to incriminate drought as responsible for locust outbreaks in the Philippines.

That climate is definitely influenced by sunspot fluctuations, at least in certain parts of the earth, is proven in a general way by Clough (1933). Ward (1922) points out that "eleven-year period-fluctuations in temperature, rainfall, and certain other meteorological phenomena has been made out by several investigators," although he cautions, citing C. E. P. Brooks, that "so far as the effect of a variation of short period like that of the sunspots is concerned, it seems highly probable that the effects are so many, so complex, and so mutually interdependent that the periodic cause undergoes its next change before its effects are everywhere fully established. . . . . The sunspot period being so short, 'repercussions' do not die down sufficiently to allow a clear vision of the relation between the solar cause and the terrestrial effect." Visher (1924), likewise, adds that "the fact that different areas respond in opposite ways to changed solar activity has done much to conceal the relationship between solar changes and terrestrial weather, for wherever the rainfall of large regions are compared, the excessive rainfall received in one part may offset the deficient rainfall of another part."

For purposes of the present work, representative Weather Bureau stations are selected on the basis of geographical location and with respect to peculiarities in climatic features which, as will be shown in a separate paper by the writer, apparently represent con-


● Group A
⊙ Group B
○ Group C
Batan Islands
Balintang Channel
Babuyan Islands
CHINA SEA
PACIFIC OCEAN
Polillo I.
Lamon Bay
Lubang I.
MINDORO
Mindoro Strait
Marinduque I.
Catanduanes I.
San Bernardino Channel
Romblon I.
Sibuyan I.
Busuanga
Calamianes Is
Culion I.
Cuyos Is
SAMAR
PANAY
LEYTE
BOHOL
Dumaran I.
Kagayanes Is
Cavilli I.
Tub Bataha
SULU SEA
Siquijor I.
Camiguin I.
Dapitan Bay
Iligan Bay
Sindangan Bay
MINDANAO
DAVAO DISTRICT
COTABATO DISTRICT
Davao Gulf
Basilan Strait
Basilan I.
Balabac I.
Kagayan Sulu
BORNEO
SULU DISTRICT
SULU ARCHIPELAGO
CELEBES SEA
Sarangani Bay
Sarangani Is.
118°
120°
122°
124°
126°
20°
18°
16°
14°
12°
10°
8°
6°

Map of the Philippines, showing location of weather stations in Groups A, B, and C.

ditions favorable to the production of locust swarms. These are classified into three groups in gradated series, according to degree of susceptibility. Manila is also used, although the climatic conditions in this station are apparently not conducive to migratory-swarm production. It has the longest set of records, those for temperature and rainfall dating back to 1870, or 66 years. Moreover, the data from this station are the most readily available, so that, if any common trend with the more southern stations can be established, future attempts at forecasting might be greatly facilitated.

Group A (most highly susceptible)

Davao, 1903 to 1923; 1925 to 1934	31 years.
Cagayan de Misamis, 1909 to 1910; 1912 to 1934	25 years.
Cotabato, 1906; 1908 to 1910; 1912 to 1934	27 years.
Dumaguete, 1910 to 1934	25 years.
Tagbilaran, 1903 to 1935	33 years.

Group B (second in susceptibility)

Capiz, 1903 to 1935	33 years.
Iloilo, 1903 to 1935	33 years.
Bacolod, 1903 to 1908; 1921 to 1923; 1926 to 1933	17 years.
Cebu, 1903 to 1935	33 years.
Maasin, 1903 to 1934	32 years.
Ormoc, 1903 to 1934	32 years.
Tacloban, 1904 to 1935	32 years.

Group C (third in susceptibility)

Virac, 1908 to 1933	26 years.
Naga, 1916 to 1934	19 years.
Masbate, 1910 to 1934	25 years.
Atimonan, 1903 to 1935	33 years.
Calapan, 1909 to 1932	24 years.
Daet, 1920 to 1933	14 years.
Legaspi, 1903 to 1935	33 years.

From the relationship shown in charts 1 and 2, the following year groupings for every station were made:

1. Sunspot high (or maxima)—years in which the mean sunspot area is above 500 millionths of the visible solar hemisphere; locust fluctuation at low ebb: 1870 to 1874; 1881 to 1885; 1891 to 1895; 1905 to 1909; 1915 to 1920; 1925 to 1929.
2. Sunspot low (or minima)—years in which the mean sunspot area is 500 millionths and below; stage set for locust swarms: 1875 to 1880; 1886 to 1890; 1896 to 1904; 1910 to 1914; 1921 to 1924; 1930 to 1935.

Following the method suggested by Shelford (1927), mean monthly temperature plotted in Cartesian coördinates against rainfall of the different Weather Bureau stations in the respective groups were combined for each month and a line drawn to circumscribe the area thus marked. A diagram was prepared for each group for years of sunspot high and another for sunspot low. Then the centers of the circumscribed areas were taken and used in Ball-Taylor diagrams. Charts 3 to 12 give the results. In chart 11 the Ball-Taylor diagrams of years of sunspot high (dotted lines) are superimposed on those of sunspot low (solid lines). Chart 11 also includes the composite Ball-Taylor diagrams with reference to sunspots and with reference to actual occurrence of locusts for Manila, as well as that borrowed from an unpublished paper of the writer in which the average climatic features of non-habitual locust areas (dotted lines) are superimposed on those of habitual locust areas. The following general deductions seem to be justified from a comparative study of these diagrams:

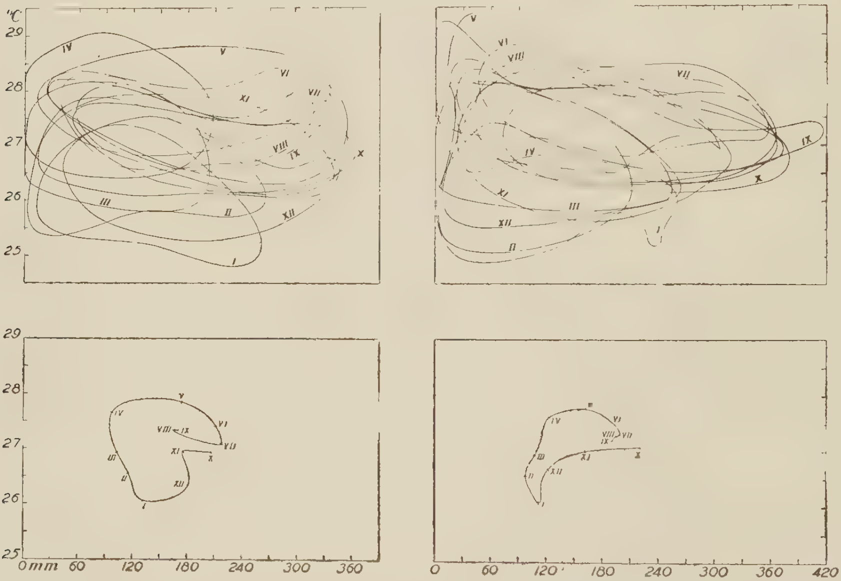


Chart 3.—Group A, temperature-rainfall diagrams. Above, left, monthly limits of temperature-rainfall in years of sunspot high; right, in years of sunspot low. Below, centers of figures for each month in diagrams above. For explanation, see text, p. 337-340.

In the regions considered, the effect of solar fluctuation on temperature and rainfall appears to be most pronounced in stations below latitude 10°N (Group A). The difference between the temperature-rainfall trends in years of sunspot high and those in sunspot low apparently diminishes progressively as the higher latitudes are reached.

Group A is characterized in years of sunspot low by generally higher temperature from October to December, and less rain from November to February. December is particularly much warmer and drier than the corresponding month in years of sunspot high.

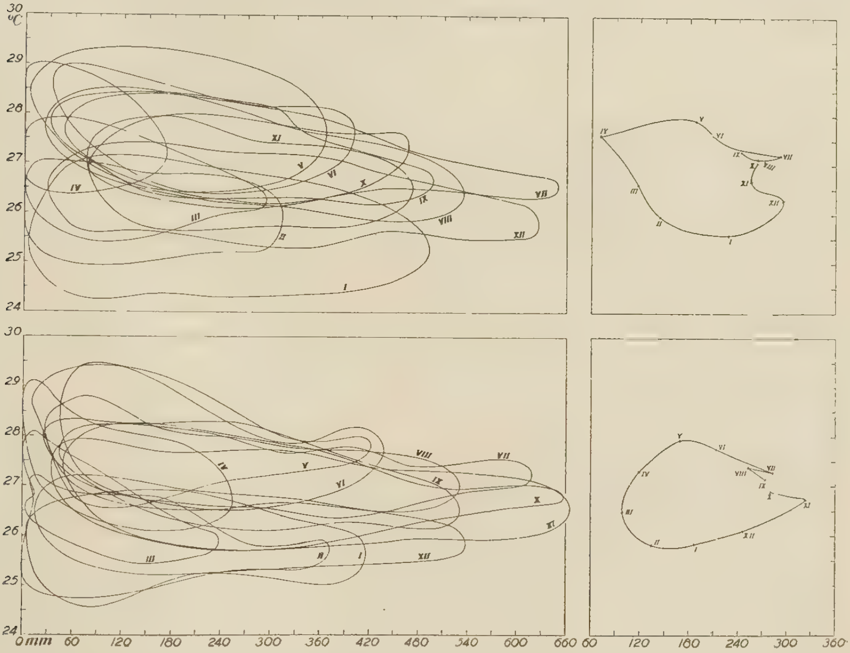


Chart 4.—Group B, temperature-rainfall diagrams. Left, above, monthly limits of temperature-rainfall in years of sunspot high; below, in years of sunspot low. Right, centers of figures for each month in diagrams to the left. For explanation, see text, p. 337-340.

April and May temperatures are noticeably lower and April is markedly wetter. In general, years of sunspot low in Group A exhibit closer uniformity and more gradual temperature-rainfall gradients throughout the year.

The higher November (or October) to January temperature in years of sunspot low is also shown in the other groups. Groups B and C, likewise, share with A the fact that December and January are markedly drier than their corresponding months in years of sunspot high. Moreover, April is cooler and somewhat wetter.

That at least a prevailing warmer temperature from October to January in all stations apparently characterizes years of sunspot low, which are taken in the present paper as years of locust outbreaks, is supported by the fact that this tendency is reflected even in the Manila station (see chart 11, Manila, superimposed climatographs for years of sunspot high and years of sunspot low; also Manila, locust and non-locust years). Likewise, the superimposed diagrams for the Philippines, non-habitually and habitually locust-infested districts (chart 11), exhibit the same relative behavior. A further corroborative evidence is furnished in chart 12, wherein the superimposed climatographs for Groups A, B, and C show marked contrasts in these months, being highest in Group A and lowest in C, in years of sunspot low, while they are almost confluent in years of sunspot high.

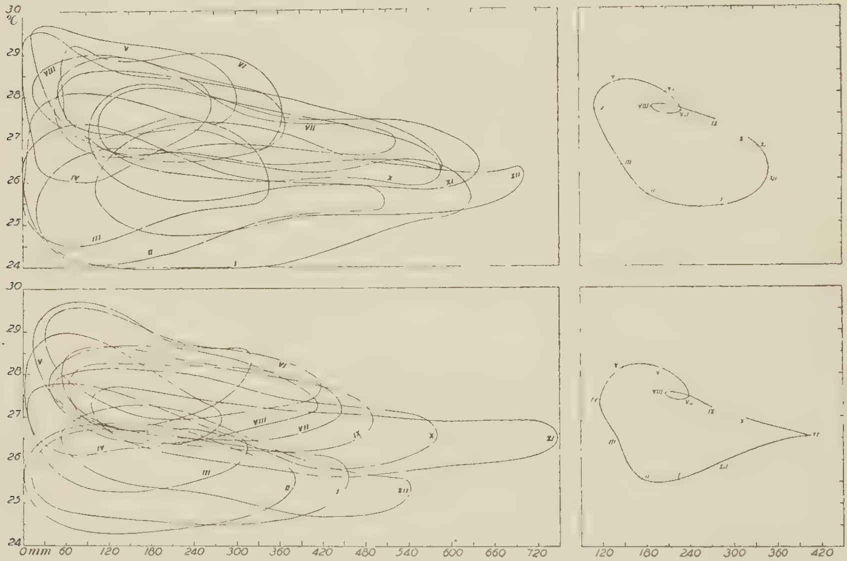


Chart 5.—Group C, temperature-rainfall diagrams. Left, above, monthly limits of temperature-rainfall in years of sunspot high; below, in years of sunspot low. Right, centers of figures for each month in diagrams to the left. For explanation, see text, p. 337-340.

The increasingly more copious November rainfall in latitudes higher than 10°N in years of sunspot low than in years of sunspot high is probably an important deterrent to locust-swarm formation in these more northern areas. It might perhaps furnish a clue as to why Philippine localities in Group C are less subject to locust infestation than those in Group B, and those in Group B, than those in Group A. Notice should, moreover, be taken of the fact that monthly precipitation in July to December in all years, irrespective of sunspots, is generally greater in Groups B and C than in A.

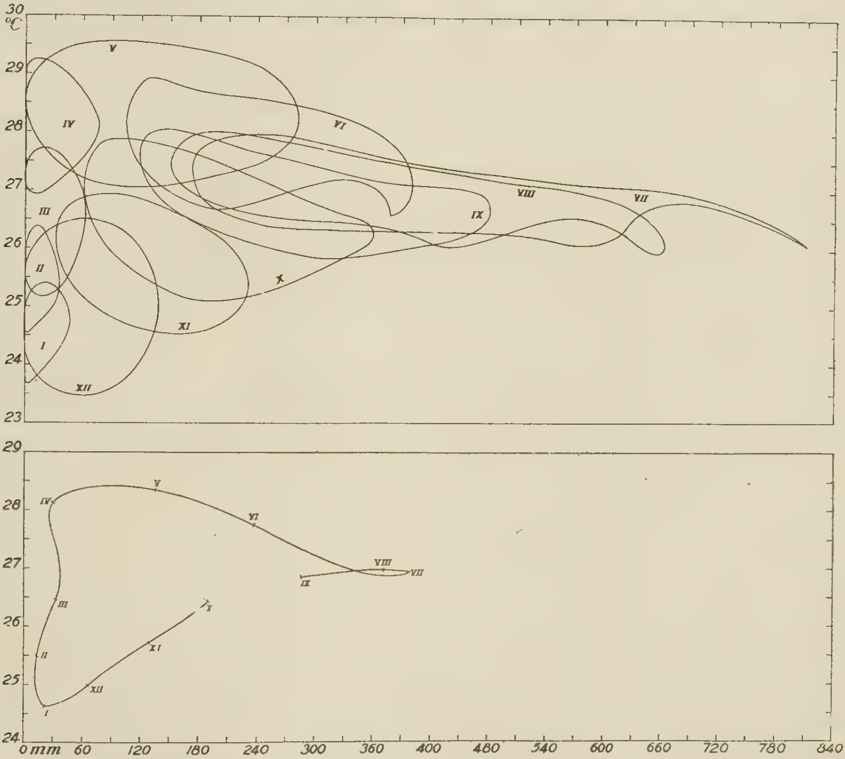


Chart 6.—Manila, temperature-rainfall diagrams, years of sunspot high. Above, monthly limits of temperature-rainfall. Below, centers of figures for each month in diagram above. For explanation, see text, p. 337-340.

In chart 10 (temperature-relative humidity diagrams for Manila), July, August, September and October, and especially the first three months, are much closer together in years of sunspot low than they are in years of sunspot high. This behavior doubtless follows largely the trend of rainfall distribution, as shown in chart 11. November to January are warmer in years of sunspot low, although relative humidity does not appear to exhibit much difference. March is warmer and more humid, although in chart 11 less rainfall is indicated, probably because the higher temperature induces greater surface evaporation and also enables the air to hold more moisture. Unfortunately, more complete data on relative humidity for the more southern stations were not available to the writer, so that no comparison could be made.

The relation of drought to locust outbreaks in the Philippines cannot be proved conclusively through the use of Shelford and Ball-Taylor diagrams, inasmuch as this method shows only combined general trends of two climatic factors plotted in Cartesian coördinates. However, the diagrams for years of sunspot low show marked dryness for February and, in the stations in the more northern latitudes, also March. These months also grow comparatively warmer than in years of sunspot high, the difference increasing with distance from the equator. In table 1, moreover, practically all the drought years indicated coincided with locust years.

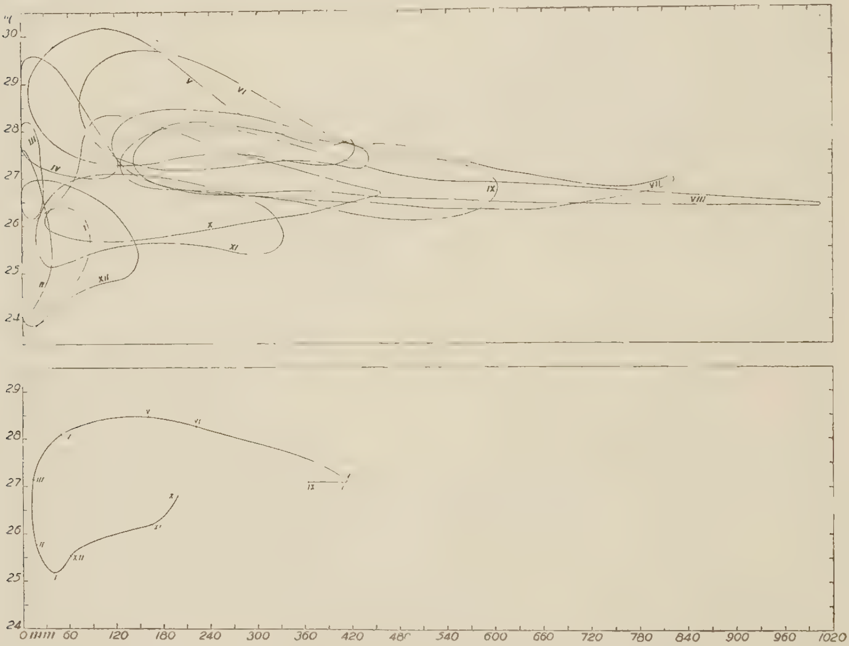


Chart 7.—Manila, temperature-rainfall diagrams, years of sunspot low. Above, monthly limits of temperature-rainfall. Below, centers of figures for each month in diagram above. For explanation, see text, p. 337-340.

SOME PRACTICAL CONSIDERATIONS

It is, of course, regrettable that no continuous quantitative data on locust outbreaks in the Philippines are available for a much longer period. However, the twenty-four year record, from 1912 to 1935, used in the curve-parallel diagrams in chart 2 and in the calculation of the coefficient of correlation, cover over two locust cycles. In addition, the earlier fragmentary records of over three and a half centuries serve as supplementary evidence, which, taken together, furnish what appears to be a sufficiently adequate basis for forecasting.

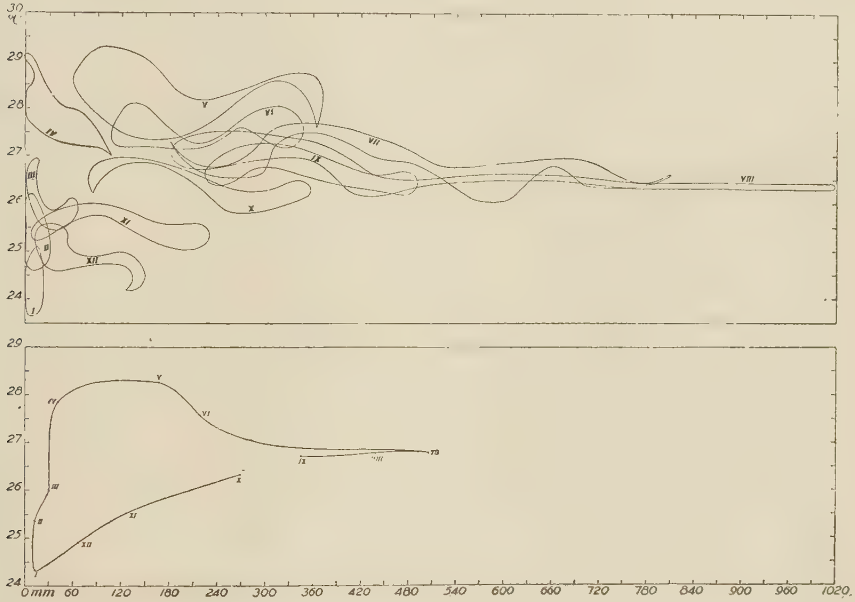


Chart 8.—Manila, temperature-rainfall diagrams, non-locust years. Above, monthly limits of temperature-rainfall. Below, centers of figures for each month in diagram above. For explanation, see text, p. 337-340.

A great deal of precise determination, under controlled conditions, must have to be done, on the specific biological reactions of the Oriental migratory locust to the various physical, as well as organic, factors in its environment in order that definite conclusions could be made on such questions, for instance, as exact climatic features underlying production of the gregarious phase. Such problems are admittedly very complex. They will doubtless require time and, what is more important, special facilities for their solution. In the meantime, advantage may be taken of such clues as have been gathered in the present work, at least by way of suggesting some possible lines to follow in research on the locust problem in the Philippines.

The standard weather data, as taken by the Weather Bureau, express conditions at some distance above the surface of the ground, and do not necessarily give an exact picture of the locust's ecoclimate. However, important contrasts were noted in the composite climatographs between years of sunspot high and those of sunspot low. These dissimilarities were most prominently accentuated in stations in Group A and least in Group C. Locust-swarm intensity and persist-

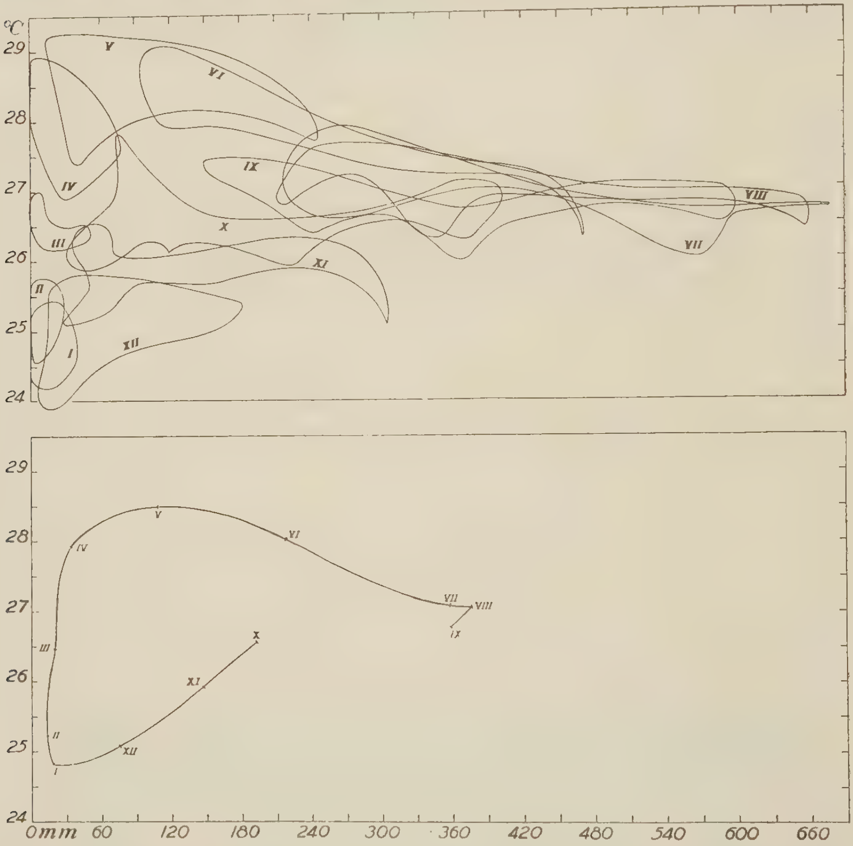


Chart 9.—Manila, temperature-rainfall diagram, years with widespread locust outbreaks. Above, monthly limits of temperature-rainfall. Below, centers of figures for each month in diagram above. For explanation, see text, p. 337-340.

ence are strongest in the former and weakest in the latter, in the three station-groups that were selected on the basis of their known propensity for locust infestation. These facts would seem to point to a significant part played in the Philippines by the differential regional effect on climate of fluctuations in solar activity and its consequent influence on locust swarming.

The fairly marked negative correlation existing between sunspot area and locust outbreaks, the general occurrence of widespread infestation in years when the annual average sunspot area is 500 millionths, or less, of the visible solar hemisphere, and the low ebb of the locust cycle nearly always falling in years when the annual average reaches above 500, together give hopeful signs for the present, inasmuch as the latest sunspot figures available for five consecutive months (*Monthly Weather Review*) are: 1935—October, 629, November, 1218, December, 1317; 1936—January, 1370, February, 931. It is known that the sunspots are on the increase this

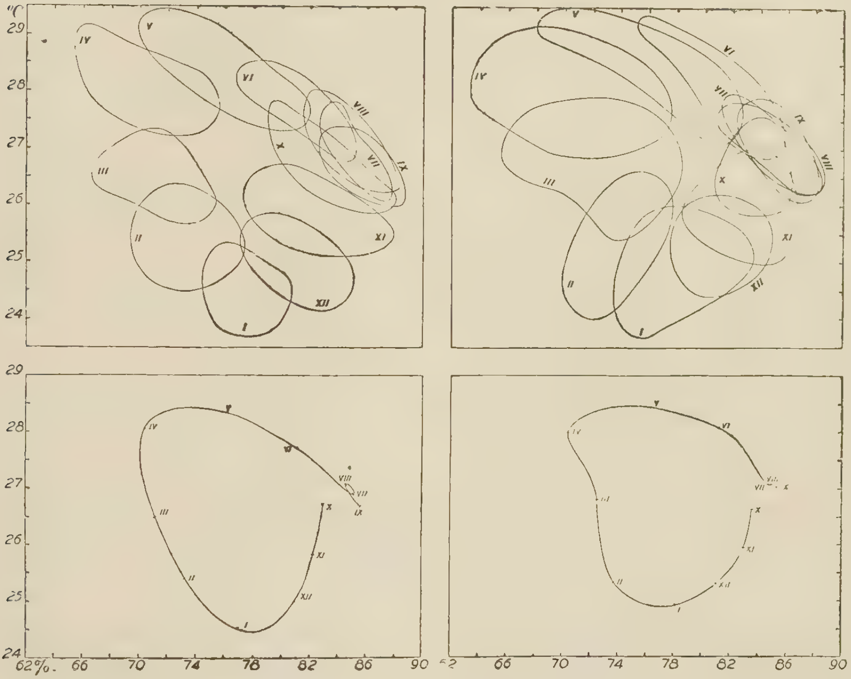


Chart 10.—Manila, temperature-relative humidity diagrams. Above, left, monthly limits of temperature-relative humidity in years of sunspot high; right, in years of sunspot low. Below, centers of figures for each month in diagrams above. For explanation, see text, p. 337-340; 343.

year, the maximum phase, according to Stetson (1936), being expected in 1938. On the strength of these data, a notice was released in the College of Agriculture *Biweekly Bulletin,* July 1, 1936, announcing that "it is, therefore, most probable that 1936 will see the beginning of a decline in locust outbreaks in the Philippines, leading to the years of low in the present cycle of infestation."

In a forthcoming paper, the writer expects to present evidence that, in his opinion, would delimit permanent migratory-locust reservations in the Philippines to a few narrowly circumscribed areas.

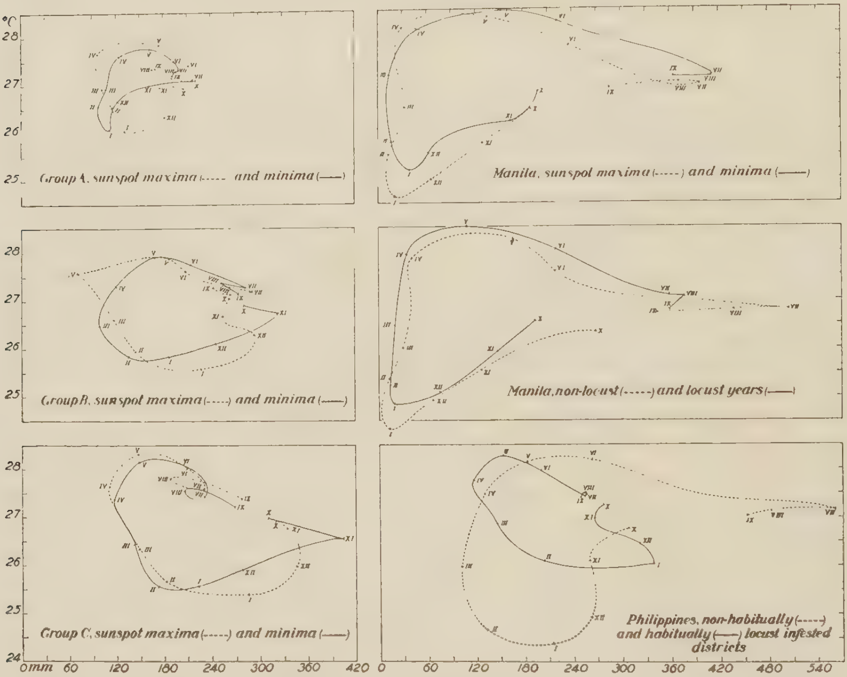


Chart 11.—Superimposed diagrams of centers of monthly limits of temperature-rainfall.

It is hoped that, if confirmed by subsequent more detailed field investigation over a longer period of years, that theory, together with the conclusions arrived at in the present paper, may give us a better chance in the Philippines to make efforts at control more telling, when we are able to foresee a forthcoming outbreak cycle in time to head off the earliest formation of swarms at their principal sources before they can spread out. Likewise, the resulting limitation of control activities to a much smaller territory than at present would mean a considerable saving.

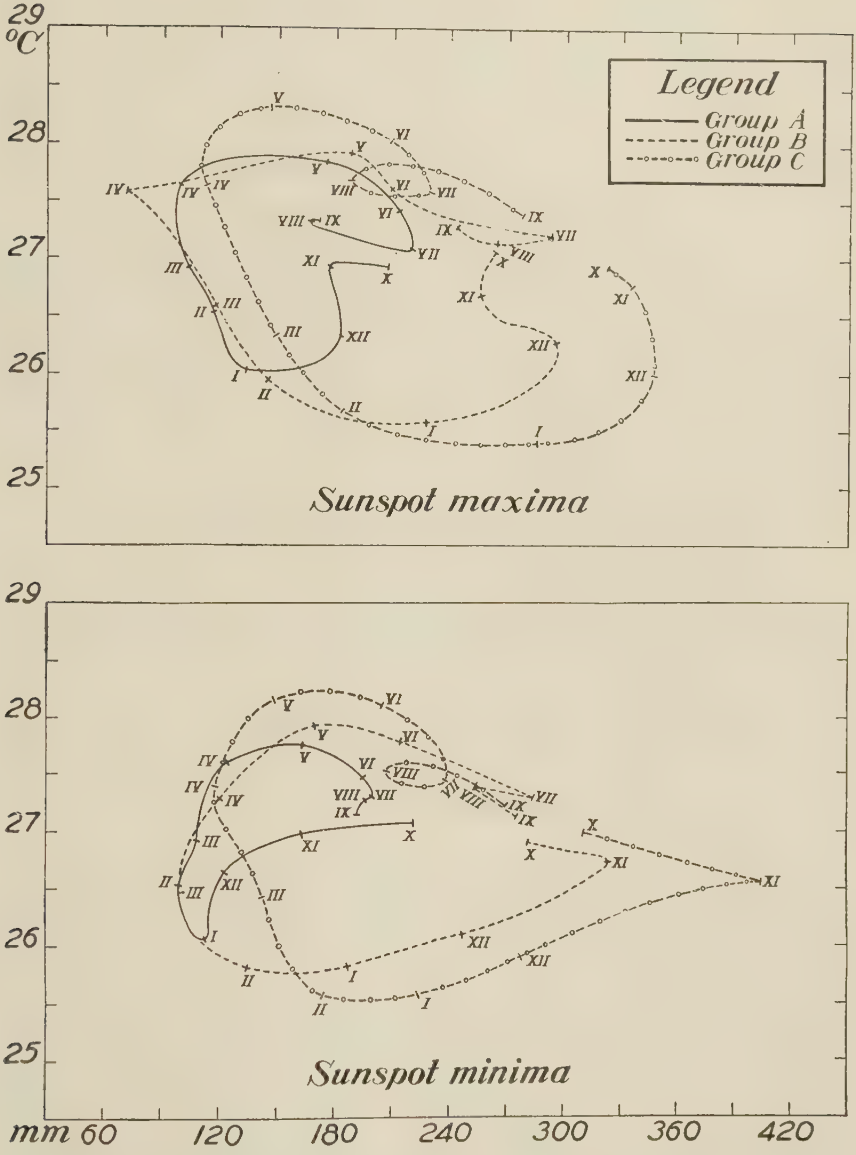


Chart 12.—Superimposed diagrams of centers of monthly limits of temperature-rainfall, Groups A, B, and C.

SUMMARY AND CONCLUSIONS

1. A compilation of pertinent excerpts from records of locust outbreaks in the Philippines is made, dating from the earliest written account, in 1569, to 1934, or a period of 365 years.

2. Inasmuch as only one form of migratory locust occurs in the Philippines, namely, *Locusta migratoria manilensis* (Meyen), there can be no confusion of identity even in the older documents which were not prepared by entomologists.

3. The average relatively locust-free interval between outbreaks in the 365 years under review is 11 years, which probably nearly represents the master cycle in locust periodicity in the Philippines.

4. There appears to be a fairly marked negative correlation between solar activity and locust fluctuation. The coefficient of correlation between sunspot area in millionths of visible solar hemisphere and annual maximum number of municipalities infested is -0.44 ± 0.111. This relationship would serve to explain the close correspondence between the probable master cycle of locust outbreaks and the 11-year average interval between sunspot minima.

5. Years in which the average sunspot area is 500 millionths, or less, of the visible solar hemisphere appear in general to give rise to conditions favorable for the gregarious phase; those with greater average area, unfavorable.

6. The damped undulation of the smoothed curve for locust outbreaks suggests the probability of the locust cycles being the amplified effect of sunspot periods as harmonic components of a major astronomical cycle.

7. The influence of solar fluctuation on temperature and precipitation appears to be most profound in Mindanao and neighboring areas south of 10°N parallel, the effect diminishing progressively with increasing latitude.

8. A common characteristic of all the stations considered is that years of sunspot low exhibit a prevailing warmer temperature from November to December or January. In the areas most susceptible to locust infestation, such as those represented by stations included in Group A (Davao, Cagayan de Misamis, Cotabato, Dumaguete, and Tagbilaran), the trend of temperature-rainfall throughout the year describes a more uniform gradient, without the abrupt changes that mark the years of sunspot high. Hence, the cooler April and May, wetter April, and drier December and January in years of sunspot

low. The last characteristic, that is, drier December and January, is also shared even by Groups B and C, which are somewhat less suitable for locust-swarm formation.

9. Relatively warmer October to January, especially the last month, and a particularly hotter and drier March in Manila apparently prognosticate impending widespread locust outbreaks in the Philippines.

10. The marked dryness during years of sunspot low in January and February or February and March and, in the more northern latitudes, also higher temperature in March suggest a probable prevalence of drought conditions as a feature of locust years.

11. On the basis of the findings in the present work, a preliminary announcement was issued on July 1, 1936, forecasting for this year the probable beginning of a decline of locust outbreaks in the Philippines, leading to the years of low in the present cycle of infestation.

12. The intended goal of the present investigation is to work out a method whereby the course of locust outbreaks in the Philippines may be foretold with reasonable accuracy and sufficiently in advance either as a measure of reassurance when the locust cycle is receding or to allow for a timely execution of repressive steps while the cycle is in the incipient stages. Because of the complexity of the factors involved, considerable additional experience alone in the future trends of locust epidemics will enable us adequately to test the criteria and methods herein used and decide whether they are dependable enough to be worth adopting in practice.

ACKNOWLEDGMENTS

Grateful acknowledgments are due Rev. Miguel Selga, S. J., director of the Weather Bureau, and Rev. Charles E. Depperman, S. J., assistant director, for weather records and important references; Dr. B. P. Uvarov, Imperial Institute of Entomology, London, for identification of specimens and some valuable suggestions; Dr. Gonzalo Merino, chief, division of plant-pest and disease control, Bureau of Plant Industry, and Mr. Faustino Q. Otanes, assistant chief, for furnishing copies of their current weekly locust reports since August 29, 1934, and also otherwise unavailable locust data for 1932 and 1933; and Mr. Arsenio Y. Coronel, assistant in entomology, College of Agriculture, for help in inking and lettering the charts.

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TABLE 1

Recorded locust-outbreak years and some of the drought years in the Philippines

LOCUST OUTBREAKS	EXTENT OF INFESTATION	DROUGHT YEAR	INTERVALS BETWEEN LOCUST PEAKS	PROBABLE CYCLE SERIES
date	*place*	*date*	*years*	*number*
1569–72	Panay			
1582–84	All islands		12	1
1597–99	All islands		15	1
1604–05	(?) Luzon		7	1
1618	All islands		14	1
1631–33	All islands		13	1
1643–45	Mindanao and Luzon (Cagayan)	1643	12	1
1656–59	Mindanao, Visayas, Luzon		13	1
1668	Luzon		12	1
1687–88	All islands (bad)		19	2
1717–18	All islands (fearful)		30	2
1731–36	All islands		14	1
1818	All islands		87	8
1854	Visayas		36	3
1860–62	Leyte, then all islands		6	1
		1865		
1879	Luzon		19	2
1886	Laguna and Batangas	1885	7	1
1895	Luzon		9	1
1903–05	All islands	1903	8	1
1909–15	All islands	1910,'12	9	1
1922–24	All islands		8	1
1932–36	All islands		13	1
Total			363	33

[Average duration of cycle (363/33) = 11 years.]

COMPARATIVE PERFORMANCE OF ALCOHOL AND KEROSENE AS FUELS WITH OR WITHOUT PRE-HEATING FOR A FORDSON TRACTOR[1]

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Of the Department of Agricultural Engineering

WITH ONE TEXT FIGURE

INTRODUCTION

Importance of the problem

The use of alcohol as a substitute fuel for both stationary and traction engines is gaining wide recognition in the Islands. Many car owners are using alcohol as fuel and many owners of tractors have changed from kerosene to alcohol. A few corporations and some sugar centrals have directed their attention to the manufacture of alcohol for motor fuel from sugar cane molasses. Although considerable testing work of different kinds has been done with alcohol, little has been done in comparing its performance as fuel for tractors with that of kerosene.

Unlike in laboratory tests where the different factors which can affect the performance of the engine can be controlled by the experimenter, in the field these are difficult to control owing to varying field conditions. It is therefore important before recommending alcohol as a tractor fuel to compare its performance with both alcohol and kerosene as fuels with and without pre-heating in field work.

Review of literature

Tests on the use of straight alcohol, alcohol-gasoline blends, kerosene and gasoline as fuels for different makes of gasoline engines have been undertaken but for the most part in laboratories.

Lucke and Woodward (1907) made extensive tests on the use of alcohol as fuel for internal combustion engines originally designed for either gasoline or kerosene. Six engines were used; only one was of the multi-cylinder type. Strong and Stone (1918) worked on comparative fuel values of gasoline and denatured alcohol in internal combustion engines. Four single-cylinder engines were used.

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[1] Experiment Station contribution No. 1132.

Ricardo (1921-22) made a very thorough study of the use of alcohol fuels using a variable compression engine of his own design for the tests. Teodoro (1931) carried out alcohol fuel tests using multicylinder tractor engines as prime movers. Teodoro and Banzon (1932) made tests using alcohol blends and kerosene-Diesel fuel mixtures for tractor engine of the McCormick-Deering Power Unit Model 300. Cruz and Ang (1932) worked on the use of denatured alcohol and gasanol as fuels for small stationery gas engines. All of these tests showed that alcohol fuels can be used as fuel for engines originally designed for either kerosene or gasoline.

Bench tests conducted by Teodoro (1935) using different grades of nearly straight alcohol for new models of motor vehicles, like the Chevrolet, Waukesha motor and Ford V-8, showed that with the Chevrolet: (1) no difficulty in starting was found with the use of alcohol fuels; (2) the engine operation at or near the full load with the alcohol fuels was steadier than with gasoline. At low speeds, however, operation with gasoline was a little better than with alcohol fuels.

Teodoro (1935) further found with the use of a Waukesha motor: (1) that, with fixed carburetor setting, higher power was developed without than with pre-heating; (2) that without any preheating the engine missed occasionally at light loads and at low speeds. Using a Ford V-8 engine, Teodoro further noted (1) that in general, constancy in operation at higher loads could be maintained for a longer time with alcohol-gasoline mixtures than with gasoline; (2) that in general the mixture containing the least amount of gasoline had the highest efficiency.

Catambay and Cuevas (1935) found from field study that the cost of operating a Fordson tractor with the use of alcohol was cheaper than with the use of kerosene.

Objects of the work

The objects of the present study were: (*a*) to determine fuel consumption using kerosene as fuel with and without pre-heating; (*b*) to determine the fuel consumption using alcohol as fuel with or without pre-heating; (*c*) to determine the crankcase oil consumption and dilution with kerosene and alcohol as fuels; and (*d*) to determine the cost of plowing a hectare by using the two fuels with and without pre-heating.

Time and place of work

The work was conducted in the Experiment Station fields of the College of Agriculture at Los Baños, Laguna and in the fuel and lubricant laboratory of the Department of Agricultural Engineering of the same College. The work covered the period from April, 1935 to January, 1936.

MATERIALS AND METHODS

Tractor

A Fordson tractor which was lent by the Manila Trading and Supply Company was used in this work.

According to the manufacturer, the tractor has the following specifications:

Engine—41/8″ × 5″, 4–cyl., 267 cu. in. displacement. 30 B.H.P. at 1000 R.P.M. with gasoline fuel and 77 lb. compression. 26 B.H.P. at 1000 R.P.M. with kerosene fuel and 67 lb. compression. Crankshaft hardened, and carefully balanced. Pistons—light weight, die cast iron-51/16″ long, 4 piston rings used 5/32″ wide. Three main bearings 2″ dia. × 3″ long. Connecting rod—91/2″ long—lower bearing 2″ dia. × 21/4″ long. Kerosene vaporizer 11/4″ Kingston Hot Plate type. Valves, chrome silicon alloy steel, 13/4″ head dia., stems 11/32″ dia.

Cooling—Centrifugal pump, 18″ diameter 4–blade fan; tube radiator, capacity 111/2 gal.

Ignition—High tension magneto, impulse coupling. Manual spark advance. Automatic retard for cranking. Spark plugs 7/8″ S.A.E.

Lublication—Circulating splash. Flywheel pump. 7″ filter screen. Oil capacity 21/2 gal.

Air cleaner—Water type with float. Integral with dash. Capacity 17 quarts.

Clutch—Multi disc in oil. 17 hardened plates. Lever provided for holding in release position.

Transmission—Three-speed and reverse. Constant mesh. Internal gear clutch for each speed. Heavy duty straight roller bearings. Gears 5–7 pitch chrome alloy steel.

Steering—Enclosed bevel pinion and sector. 18″ dia. rubber covered steel steering wheel. Turning circle 21 feet.

Fuel tank—Capacity 20 gal. Reserve tank 5 quarts. Two-way valve with strainer and sediment chamber.

Front axle—Heat treated steel I-beam forging.

Front spring—Helical type mounted at center of axle.

Rear axle—Semi-floating worm drive. Worm hardened and ground and mounted at each end on double roller bearings. Phosphor bronze wheel. Ratio 17 to 1. Axle shaft 2″ dia. high carbon steel hardened and ground.

Brake—Multiple disc on transmission. 16 hardened plates. Operated by clutch pedal.

Front wheels—Cast iron 30″ dia. × 5″ wide. Taper roller bearings.

Rear wheels—Steel, 42″ dia. × 12″ wide, 14 angle cleats 3″ high. 7″ extension rims extra. Straight roller bearings lubricated from worm housing.

Fenders—Heavy gauge steel, braced at 6 points, includes platform and tool box.

Weight—Fully service 3310 lb. Front–1360 lb. Rear–1950 lb.

Pre-heating device

The tractor used is provided with a vaporizing plate with grooves through which the fuel vapor passes from the carburetor to the mixing chamber. This plate, being attached to the exhaust manifold, is heated by the exhaust gases. The term "without pre-heating" as often used in this paper does not mean that the fuel vapor was not heated at all for it is partially heated as it passes through the vaporizing plate groove which has an average depth of 0.8 cm. In the sets of tests where more heating of the fuel vapor was necessary, that is, with pre-heating", another vaporing plate much thicker than the first and with a groove with an average depth of 1.14 centimeters was used. The groove being deeper and its width the same, the fuel vapor is exposed to more heated surface with this plate than with the 0.8 cm. plate. This vaporizing plate is illustrated in figure 1.

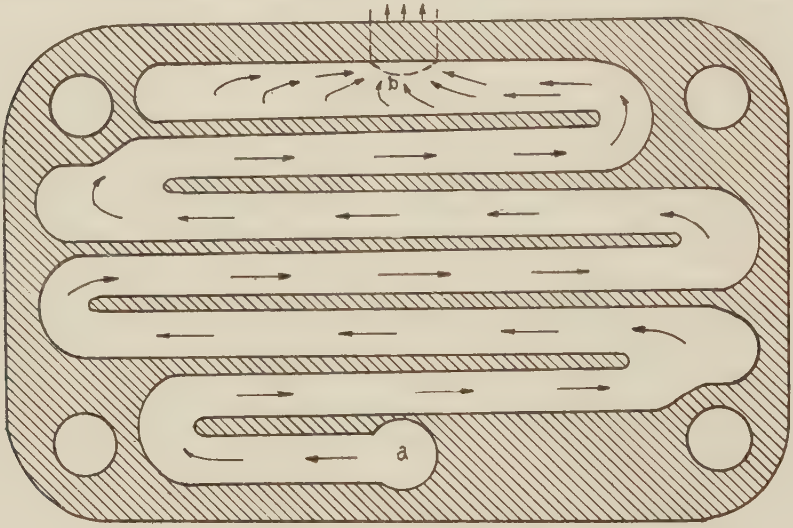

Fig. 1.—Vaporizing plate. Fuel from the carburetor (called kerosene vaporizer) enters at *a* where vaporization begins. Further vaporization and heating take place as the vapor travels along the groove of the vaporizing plate. The heated fuel vapor passes through *b* into the mixing chamber. This plate is attached to the exhaust manifold and is heated by the exhaust gases.

Plow

A 2-24 inch disc plow which had been mounted at the right side of the tractor by the manufacturer was used for plowing.

Fuels used

Alcohol. The alcohol fuel used was Alkohl Motor fuel with a specific gravity of 0.8255 at 15°C. The fuel came from the distilleries of the Calamba Sugar Estate.

Kerosene. The kerosene used has a specific gravity of 0.842 at 15°C.

Gasoline. Gasoline was used only in starting the engine when kerosene was used as fuel.

Other equipment used

The lubricating oil used has a viscosity number 50 (S. A. E.)

Other pieces of equipment were: An ordinary watch for determining the time spent in plowing, a 25-ml. graduated cylinder to measure volumes, a tin funnel for filling tank with fuel, an electric oven, aluminum crucibles and balance for determining soil moisture content, and an oil dilution apparatus to determine the dilution of the oil used.

Methods

Plowing. Generally, each morning plowing constituted a trial and each afternoon plowing, another. There were some cases, however, when a morning and afternoon plowing on the same day were combined to form a trial. In all of the trials made the lever controlling the depth of plowing was locked at the eighth notch from the outer end. At this notch, the depth of plowing varied from 15 to 23 cm. and the width of cut averaged 60 centimeters.

In all the trials made the tractor was operated at second or plowing speed. The throttle governor control was fixed at the fifteenth notch from the outer end. At the second gear and at this throttle opening, the tractor gave a speed of plowing from 4.12 to 4.83 kilometers an hour.

There were two sets of plowing or trials with the use of either kerosene or alcohol fuel; one set with the use of a pre-heating device and the other without. In all the tests, with or without pre-heating, the fuel needle valve was adjusted at 1¾ turns.

The fields plowed were rectangular in shape with widths varying from about 100 to 150 meters and lengths from 300 to 400 meters. All plowing was done crosswise of the field.

The soils in the fields plowed are generally of the clay loam type with varying moisture content. All plowing was first plowing. The fields had been planted to corn, cotton, or sugar cane.

The time in hours of actual plowing in each test was recorded. The time when actual plowing was begun and when stopped was noted. The time wasted in stops as a result of engine trouble was not included in the time record.

The labor cost was computed by using the number of hours of actual plowing. The tractor driver was paid ₱0.10 an hour.

During the time of actual plowing, observations were made as to the operating features of the engine. The behavior of the engine and all trouble it had were noted.

Determination of fuel consumption. The actual fuel consumption was determined by first filling the tank up to a certain mark at the filler neck. After plowing, the tank was again filled to the same full mark and the amount used to fill it noted. This amount was considered as the fuel consumption for the area plowed.

With kerosene as fuel the volume of gasoline which was used for starting was also determined.

Oil dilution and consumption. Before each set of tests, the crankcase was filed with 9000 milliliters of new oil. After about 50 hours of use, the amount of oil in the crankcase was again measured. This used oil as a result of dilution was a mixture of oil and fuel. The percentage of dilution was determined and the actual amount of oil in the mixture was computed. The difference between the amount of new oil and the amount of oil in the mixture was considered the oil actually consumed.

In the determination of the percentage of dilution of crankcase oil, the A. S. T. M. method D322–30T was used. Catambay and Cuevas (1935) briefly described this method. In using the apparatus figured by those authors, 500 ml. of water were placed in the flask and 25 ml. of the oil sample added to the water. The flask was connected to a special receiver, which in turn was connected to the reflux condenser, cooled by running tap water. Heating of the flask was so regulated that boiling started within 7 to 10 minutes. The oil had a high boiling point so only the diluent (the fuel that leaked through the piston rings and mixed with the crankcase oil) went to the condenser with the steam and refluxed back to the receiver. Water having a higher specific gravity than the oil fell to the bottom of the receiver and slowly flowed back to the flask. The diluent remained trapped, floating on the water in the graduated arm of the receiver, where the volume was read directly after every

15 minutes for high dilutions. When the volume of diluent caught did not increase 0.1 ml. in a 15-minute intervals, the test was considered complete. The final reading was taken when the distillate was at room temperature. This reading multiplied by four was the percentage of dilution, because the sample used was one-fourth of 100.

Water consumption. The water consumption was determined from the water used in the radiator during each test. The same method as that employed in the determination of fuel consumption was used.

Soil moisture. The moisture of the soil in the field plowed in each test was determined. Samples from different parts of the field were taken at random from the furrow slice as soon as they were turned over. A known weight of each sample was dried to constant weight in an oven. The percentage of moisture in the soil was then determined.

EXPERIMENT AND RESULTS

The results of this experiment are shown in tables 1 to 30.

Table 1 shows the oil consumption with kerosene and alcohol as fuels and without pre-heating. It also shows the oil dilution.

Table 2 shows the comparison of the itemized cost of plowing per hectare. The itemized costs were obtained from the following computations:

Kerosene with pre-heating per hectare.

(1) Cost of fuel: ₱0.10 × 52.26 liters	₱5.226
(2) Cost of gasoline for starting: ₱0.12 × 0.911 liters	0.109
(3) Cost of oil: $\frac{₱0.48 \times 9 \times 7.243}{50}$ (The oil used was 9 liters at ₱0.48 a liter. It was used for 50 hours. It took 7.243 hours to plow a hectare.)	0.626
(4) Depreciation of tractor and plow: $\frac{₱2150 \times 0.10 \times 7.243}{8 \times 140 \times 9}$ (The tractor and plow cost ₱2150. Their life is estimated at 8 years and the average number of working days during the year is 140 at 9 working hours a day.)	1.542
(5) Interest on the cost of tractor and plow at 10 per cent per annum: $\frac{₱2150 \times 7.243}{365 \times 9}$	0.474

(6) Cost of man labor at ₱0.10 per hour: ₱0.10 × 7.243	0.724
Total cost of operation	₱8.701

The charges for the use of the tractor and plow were computed from the following formulas by Catambay (1931).

$$\text{Depreciation in pesos} = \frac{cd}{ym}$$

$$\text{Interest in pesos} = \frac{crd}{365}$$

where c—the cost of implement or machinery.
d—number of 9-hour days used.
m—maximum number of days used in one year.
y—number of years of life of the implement or machinery.
r—annual rate of interest.

This method of computation was also used in determining the different items of expense with the use of alcohol as fuel.

Table 3 shows the summary of results.

DISCUSSION OF RESULTS

Fuel consumption

Kerosene as fuel. The consumption of kerosene with pre-heating was 7.32 ± 0.158 liters an hour or 52.26 ± 0.799 liters per hectare; without pre-heating, 7.94 ± 0.061 liters an hour or 55.33 ± 0.539 liters per hectare. The consumption with pre-heating was a little less than without pre-heating. The smaller consumption is due to the vaporization being more complete with the pre-heated. A unit volume of fuel occupies a larger volume when pre-heated than when not. However, there was actually less fuel in the mixture. It took 1.06 times as much kerosene to plow one hectare of land without pre-heating than with the same fuel pre-heated.

Alcohol as fuel. The consumption with pre-heating was 8.14 ± 0.089 liters an hour or 59.56 ± 0.429 liters per hectare; without pre-heating it was 8.84 ± 0.098 liters an hour or 64.29 ± 0.899 liters per hectare. It may be noted that as in the use of kerosene, there was less consumption with pre-heating. Less fuel was actually present in the mixture because of complete vaporization. Heating resulted in a complete vaporization and expansion of the fuel so that actually there was less fuel per unit volume of mixture than when the fuel was not heated. It took 1.08 times as much alcohol by volume without pre-heating as when it was pre-heated.

Comparison of consumption of the two fuels. Without pre-heating the consumption of kerosene as fuel was 7.94 ± 0.061 liters an hour or 55.33 ± 0.539 liters per hectare; and of alcohol as fuel, 8.84 ± 0.098 liters an hour or 64.29 ± 0.899 liters per hectare. These figures show that there was more fuel consumed when alcohol was used. This result may be expected because to produce the same power more alcohol is needed than kerosene, as the kerosene has a higher heating value than alcohol. By volume, without pre-heating it took 1.17 times as much alcohol as kerosene to plow one hectare of land.

With pre-heating the amount of fuel required to plow one hectare of land with kerosene as fuel was 7.32 ± 0.158 liters an hour or 52.26 ± 0.799 liters; with alcohol, 8.14 ± 0.089 liters an hour or 59.56 ± 0.429 liters. From these figures, it is obvious that there was less fuel consumption when kerosene was used. With pre-heating, it took 1.12 times as much alcohol as kerosene by volume to plow the same area.

Comparison of time required to plow one hectare of land

Kerosene as fuel. The time required to plow one hectare of land with kerosene as fuel and with pre-heating ranged from 5.68 to 8.50 hours with a mean of 7.24 ± 0.179 hours (table 3). Using kerosene without pre-heating, it took 5.12 to 7.96 hours, with a mean of 6.98 ± 0.125 hours. These results show that without pre-heating, the time of plowing one hectare was shorter by 0.26 hour than when the kerosene was pre-heated. A probable explanation for this difference is that there was more power developed without the use of the pre-heater.

Alcohol as fuel. The time required to plow a hectare of land with alcohol as fuel with pre-heating was from 6.48 to 8.31 hours with a mean of 7.37 ± 0.113 hours; and without pre-heating, 5.74 to 7.937 hours with a mean of 7.29 ± 0.094 hours. These results show that the time of plowing with pre-heating was slower by 0.08 hour than without. One of the factors which might have been responsible for this difference was the less power developed with the use of pre-heater.

Kerosene and alcohol as fuels with and without pre-heating. It may be noted that the time required to plow a hectare with the use of kerosene with pre-heating was 7.24 ± 0.179 hours; with alcohol with pre-heating it was 7.37 ± 0.113 hours per hectare. The time required to plow a hectare was less by 0.13 hour with the use of kerosene than with alcohol. There are many factors which might have caused this difference, one is that lesser power may have been developed with the use of alcohol.

Without pre-heating, the time of plowing one hectare of land with the use of kerosene was 5.12 to 7.96 hours, with a mean of 6.98 ± 0.125 hours; with alcohol, 5.74 to 7.937 hours with a mean of 7.29 ± 0.094 hours. The results show that the time required to plow a hectare with alcohol as fuel was longer by 0.32 hour than that with kerosene.

Water consumption

Kerosene as fuel. The water consumption with pre-heating was 1.86 ± 0.055 liters an hour; without pre-heating, 1.49 ± 0.023 liters an hour. The greater water consumption with pre-heating may have been due to the fact that the engine was working at higher temperature.

Alcohol as fuel. The water consumption with pre-heating was 1.81 ± 0.054 liters an hour; without pre-heating, 1.65 ± 0.028 liters. From these results, it may be noted that there was again more water consumption when there was pre-heating.

Comparison of water consumption when using the two fuels. The water consumption with pre-heating was 1.86 ± 0.055 liters an hour with kerosene and 1.81 ± 0.054 liters an hour with alcohol. Without pre-heating, the water consumption was 1.49 ± 0.023 liters an hour with kerosene and 1.65 ± 0.028 liters an hour with alcohol. It may be seen that with pre-heating a little more water was consumed when kerosene was the fuel than when it was with alcohol. When there was no pre-heating, however, more water was consumed when alcohol was the fuel. From these results no definite conclusion can be drawn as to which fuel required the more water for cooling in the radiator.

Oil consumption and dilution

As shown in table 1, with kerosene as fuel and with pre-heating the oil dilution was 30.3 per cent. From this percentage of dilution the amount of oil actually consumed was computed to be 1,602.5 ml. Without pre-heating, the dilution was 32 per cent, with an actual consumption of 1,669.6 ml. When alcohol was used and with pre-heating, the dilution was 3.6 per cent. The computed actual consumption from this percentage of dilution was 34.8 ml. Without pre-heating, the dilution was 4 per cent. The actual consumption was 43.2 ml. In all cases, the amount of used oil drained from the crankcase was greater than the amount of new oil. The passage of the fuel between the piston rings and cylinder wall accounts for the presence of the fuel in the crankcase which was responsible for the dilution. The results show that there was slightly more dilution when there was no pre-heating. Assuming that there was the same leakage through the piston rings with both fuels, it may be assumed that one of the reasons responsible for the slightly greater dilution when there was no pre-heating was the presence of more fuel in the mixture; hence there was more chance of its escaping between the piston rings and the cylinder wall. Another reason for the greater dilution was the tendency for more complete combustion of the vaporized fuel when there was more vaporization. Thus, when there was no pre-heating, there was more unburned fuel than with pre-heating and this caused greater dilution.

The slight dilution detected when alcohol was the fuel was caused by the small amount of kerosene used as adulterant in the alcohol. This percentage of oil dilution with alcohol as fuel can not be used as a criterion of oil consumption because alcohol can not be separated from water in the process of dilution determination.

In computing the cost of oil used in plowing, 50 hours was considered as the safe period before changing the oil in the crankcase. The total area plowed during this period was recorded. The cost of oil consumed per hectare of land plowed was determined by noting the amount of fresh oil put in the crankcase, which was 9 liters, and using the current price of oil.

Cost of plowing per hectare

The cost of plowing a hectare of land with the use of kerosene with pre-heating was ₱8.70; without pre-heating, ₱8.89 (table 2). Using alcohol with pre-heating, the cost of plowing a hectare of land was ₱7.36; without pre-heating, ₱.63. From these results, it may be noted that there was a lower cost of operation with the use of alcohol than with that of kerosene. In both fuels, the cost of plowing a hectare was a little higher without pre-heating than with pre-heating. With pre-heating, it cost ₱1.34 less to plow a hectare with alcohol as fuel than with kerosene. Without pre-heating, it cost ₱1.26 less to plow a hectare with alcohol as fuel than with kerosene. With kerosene as fuel, it cost ₱0.19 less to plow a hectare with pre-heating than without pre-heating; with alcohol, there was an economy of ₱0.27 effected by using pre-heater.

In fuel alone, using kerosene with pre-heating, the cost was ₱5.27 for plowing a hectare of land; without pre-heating, ₱5.53.

Using alcohol with pre-heating the cost was ₱3.93; without pre-heating, ₱4.24. To operate the tractor with alcohol at the same fuel cost as with kerosene, without pre-heating, the price of alcohol should be 0.7 times the price of kerosene; and 0.75 times with pre-heating. The present price of alcohol is 0.55 times that of kerosene.

Behavior of the engine

Starting. The engine can not be started with kerosene. Gasoline was used for starting so that a portion of the fuel tank is set aside for this fuel. After the engine had been warmed up, the fuel was shifted to kerosene.

Alcohol as a fuel can be used for starting the engine. The engine can be started easily with alcohol, especially on hot days.

Flexibility. It was observed that when kerosene was the fuel, the tractor labored when hard spots in the field were encountered in plowing. It was then necessary to change from second to first gear. The second gear was used when plowing. When these hard spots were met, the tractor was driven backward before proceeding to plow. With alcohol, however, this difficulty was not noted. This difference in action of the engine shows that under such a condition when the tractor was working at full or nearly full load, alcohol gave a satisfactory performance, especially when the fuel was preheated.

SUMMARY OF RESULTS

The results of this study may be summarized as follows:

1. Fuel consumption without pre-heating: kerosene, 7.94 ± 0.061 liters an hour or 55.33 ± 0.539 liters per hectare; alcohol, 8.84 ± 0.098 liters an hour or 64.29 ± 0.899 liters per hectare. With pre-heating: kerosene, 7.32 ± 0.158 liters an hour or 52.26 ± 0.799 liters per hectare; alcohol, 8.14 ± 0.089 liters per hectare; alcohol, 8.14 ± 0.089 liters an hour or 59.56 ± 0.429 liters per hectare.

2. To plow one hectare of land the ratios between the consumption of the two fuels by volume were: without pre-heating, 1.17 times as much alcohol as kerosene; and with pre-heating, 1.12 times as much alcohol as kerosene.

3. By volume, it took 1.06 times as much kerosene to plow one hectare of land without pre-heating as with the same fuel but preheated. It took 1.08 times as much alcohol without pre-heating by volume as of the same fuel but pre-heated. More economy was effected by pre-heating alcohol than by pre-heating kerosene.

4. It took 7.24 ± 0.179 hours to plow a hectare of land with kerosene as fuel with pre-heating, and 6.98 ± 0.125 hours without pre-heating. There was a difference of 0.26 hour effected with pre-heating.

5. Using alcohol, it took 7.37 ± 0.133 hours to plow a hectare with pre-heating, and 7.29 ± 0.094 hours without pre-heating. It took 0.08 hour longer to plow a hectare with pre-heating than without pre-heating.

6. With pre-heating, it took 0.13 hour longer to plow one hectare of land with alcohol as fuel than with kerosene. Without pre-heating, it took 0.31 hour longer to plow the same area with alcohol as fuel than with kerosene.

7. Without pre-heating, the oil dilution with the use of kerosene was 32 per cent after about 50 hours; with pre-heating, 30.8 per cent after about the same length of time.

8. Without pre-heating, the oil consumption after about 50 hours with the use of kerosene was 1,669.6 ml.; with pre-heating, 1,602.5 ml. after about the same length of time.

9. With pre-heating, the total cost of operation with the use of kerosene was ₱8.70 per hectare; without pre-heating, ₱8.89 per hectare. With pre-heating, there was a saving of ₱0.19.

10. Using alcohol, the cost of plowing a hectare of land was ₱7.36 with pre-heating and ₱7.63 without pre-heating. It cost ₱0.27 less with the pre-heated fuel.

11. Without pre-heating, it cost ₱1.26 less to plow one hectare of land with alcohol than with kerosene; with pre-heating, it cost ₱1.34 less per hectare with alcohol as fuel.

12. To operate the tractor with alcohol at the same fuel cost as with kerosene, the price of alcohol should be 0.77 times the price of kerosene without pre-heating and 0.75 times with pre-heating. The present price of alcohol is 0.55 times that of kerosene.

13. There was no difficulty in starting the tractor engine with alcohol, especially in hot days. With kerosene as fuel, gasoline is required to start the engine.

14. Alcohol gave a better performance at heavier load than kerosene, especially when pre-heated.

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TABLE 1

Oil dilution and oil consumption for the two fuels

ITEMS	KEROSENE		ALCOHOL	
	With preheating	Without preheating	With preheating	Without preheating
Amount of fresh oil	9000 ml.	9000 ml.	9000 ml.	9000 ml.
Amount of drained oil	10690 ml.	10780 ml.	9300 ml.	9320 ml.
Dilution after about 50 hours	30.8%	32%	3.6%	4.0%
Amount of oil consumed ...	1602.52 ml.	1669.6 ml.	34.8 ml.	43.2 ml.

TABLE 2

Comparison of the itemized costs of plowing per hectare

ITEMS	KEROSENE		ALCOHOL	
	With preheating	Without preheating	With preheating	Without preheating
	pesos	*pesos*	*pesos*	*pesos*
Cost of fuel	5.226	5.533	3.931	4.243
Cost of gasoline for starting	0.109	0.110	—	—
Cost of oil	0.626	0.603	0.637	0.630
Depreciation of tractor and plow	1.542	1.487	1.570	1.554
Interest on the cost of tractor and plow	0.474	0.456	0.482	0.477
Cost of man labor at ₱0.10 per hour .	0.724	0.698	0.737	0.729
Total cost of operation	8.701	8.887	7.357	7.633

TABLE 3

Summary of results for all tests[a]

ITEMS	KEROSENE		ALCOHOL	
	With pre-heating	Without pre-heating	With pre-heating	Without pre-heating
Fuel consumption in liter per hour	7.321 ± 0.158	7.944 ± 0.061	8.142 ± 0.089	8.839 ± 0.098
Fuel consumption in liters per hectare	52.261 ± 0.799 (kerosene) 0.911 ± 0.047 gasoline[b]	55.328 ± 0.539 (kerosene) 0.920 ± 0.028 gasoline[b]	59.555 ± 0.429	64.291 ± 0.899
Water consumption in liters per hour	1.857 ± 0.055	1.489 ± 0.023	1.806 ± 0.054	1.648 ± 0.028
Number of hours to plow one hectare	7.243 ± 0.179	6.979 ± 0.125	7.369 ± 0.113	7.294 ± 0.094
Cost of plowing one hectare	₱8.701	₱8.887	₱7.357	₱7.633

[a] Each series of test consisted of 14 days plowing.

[b] Gasoline was used as starting fuel.

ABSTRACTS [1]

A study of different methods of rapid propagation of important College seedling canes. PANTALEON H. DE LOS REYES. (*Thesis presented for graduation, 1933, with the degree of Bachelor of Science in Agriculture No. 502; Experiment Station contribution No. 1133*).—The main object in this study was to discover methods that may be used in a rapid propagation of seedling canes under College conditions.

Fourteen P. B. (Plant Breeding) seedling-cane varieties were used as propagating stock.

The author used four methods of propagation: cut-back, splitting, combination of cut-back and splitting, and modified "rajoengan".

The planting materials for the first cut-back planting were obtained from the original cane field in which the canes were eight months old; for the second cut-back planting, the materials were obtained from ratooned canes six months old propagated in the original field and the third cut-back planting materials were obtained from split canes about five months old. Stools with the least number of young shoots were cut back.

The first planting materials used in the splitting method were obtained from the original cane field from canes about six months old; for the second planting, from the ratooned canes about five and one-half months old; and for the third planting from the second split canes about five months old.

In the combination method, the materials for the first planting were taken from the ratooned canes which were about six months old, and for the second planting from the first planting when the canes were five months old.

In the modified "rajoengan" method, the stools were topped, but care was taken not to cut any visible node. The stalks were cut in two in the middle. The upper half of each stalk was inserted into the soil and allowed to root and produce shoots. Side-shoots, or "lalas", at the height of 30 cm. were cut from the stalks and used for planting materials.

There were four plantings made during the progress of the work. In the first planting, cut-back and splitting methods of propagation were used. There was a separate planting for each method and each variety was planted in one or more adjacent rows. In the second and third plantings each of the three methods of propagation was used separately. Each variety was also planted in one or more adjacent rows. The first planting was made in lot I, the second in lot II, and the third in lot III. The fourth planting, which consisted entirely of "lalas," was made in lot IV.

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[1] Abstracts prepared as part of theme work required in English 3a, College of Agriculture.

The percentage of germination, tillering habits, relative age at which canes may be propagated, and availability of the number of cuttings from each method were determined.

The following results were obtained by the author:

1. The cut-back method of propagation gave 67 to 85 per cent germination. The splitting method gave the highest percentage of germination, from 85 to 87 per cent. The modified "rajoengan" and combination methods each gave 83 per cent germination.

2. Tillering habits of canes grown by cut-back, splitting and combination of cut-back and splitting methods of propagation did not vary; they gave an average of 4.3 tillers a stool.

3. The relative age at which cut-back canes may be ready for another cutting back was found to be from 7 to 8 months; for splitting, from 4 to 5 months, and for combination method, 5 months.

4. More stools developed from the modified "rajoengan" method of propagation than from the cut-back method.

It was recommended that the combination method of propagation is to be preferred to either the splitting or the cut-back methods.

—*Abstract by Conrado C. Dinulos*

A further study on the effect of time of hatching on growth and maturity of pullets. PEDRO S. YADAO. (*Thesis presented for graduation, 1934, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 503; Experiment Station contribution No. 1134*).—This work was conducted in the College of Agriculture to determine which of three months, December, February or April is the best time for hatching chicks. A 600-egg capacity hot-water Buckeye incubator was used. There were three hatches made. In each hatching, 600 Los Baños Cantonese eggs were used, making a total of 1800 eggs for the three sets. The hatches and the number of chicks obtained were: First hatch on December 2, 1932 with 376 chicks or 65.67 hatching percentage; the second, on February 2, 1933, with 374 chicks or 63.50 per cent; and the third on April 2, 1933 with 319 chicks, or 55.33 per cent. The low percentage of hatch in April was due to the high embryonic mortality.

The chicks were brooded in a 500-chick Buckeye coal-burning brooder. In the first two weeks the brooder was kept heated from half past five in the afternoon to eight o'clock the following morning. From the second week on, the brooder was kept heated only from six o'clock in the evening to about seven o'clock the following morning, except on rainy days when the chicks needed steady heat. The chicks were kept under this condition for eight weeks, then to prepare them for the range, the length of heating was gradually shortened. The cost of brooding decreased gradually as the weather became warmer. The total cost of brooding was computed on the basis of 100 chicks. The December hatch cost ₱8.25 to brood to eight weeks of age; the February hatch, ₱5.79; and the April hatch, ₱4.94.

The lowest total percentage mortality of chicks, 16.53 per cent, was in the February hatch; the December hatch was 27.66 per cent; and the April hatch was 32.17 per cent.

The growth of the chicks was determined by their increase in weight. The differences in the rate of growth of the chicks may be attributed to the differences in weather conditions prevailing during their growing period. The December hatch was reared when the weather was neither too hot nor too dry; the February hatch in the beginning of the warm and dry season; the April hatch in the hottest and in the rainiest months.

When twenty weeks old, the pullets in the December and February hatches began to lay eggs. At this age, the December pullets were the heaviest, and the April pullets were the lightest. The differences in weights when treated statistically were significant. At the age of twenty-four weeks, the trend of growth was changed. The April pullets became the heaviest, average, 1,135.5 grams; December, 1,115.5 grams; and the February, 1,050.4 grams. The cause of differences in weight was that the April pullets were just beginning to lay eggs, while the December and February pullets had been laying for twelve weeks. Of the pullets hatched in different months, there were variations in the length of time to maturity. At the age of six months the percentage of birds that laid eggs in the December hatch was 49.60—per cent; the February hatch, 18.88 per cent; and the April hatch, 5.56 per cent.

The comparisons of the three periods of hatchings may be summarized as follows:

1. The December hatch had the highest hatching percentage; a lower percentage of mortality than the April hatch; the highest percentage of pullets that laid eggs at the age of six months; the growth of the chicks was intermediate between the February and April hatch.

2. The February hatch had the second highest percentage of hatch; the lowest percentage of mortality; the second highest percentage of pullets that laid eggs at the age of six months; and the highest rate of growth.

3. The April hatch had the lowest percentage of hatch; the highest percentage of mortality; had the lowest percentage of pullets that laid eggs at the age of six months; and the lowest rate of growth.

4. From the results obtained the December hatch produced the best pullets and the April hatch, the poorest.

—Abstract by M. P. del Puerto

Plant life at the foot of Mt. Maquiling. (J. B. Banzon photo.)

COLLEGE AND ALUMNI NOTES

From a recent issue of *Agricultural Missions Notes,* we learn with deep regret of the death of Dr. Kenyon L. Butterfield, at his home in Amherst, Massachusetts, on November 26, 1935. Doctor Butterfield was prominently identified with the rural mission of the Church in Eastern Asia, in his capacity as rural counsellor to the International Missionary Council. Since his first visit to this College in October, 1921, where he conferred with a former classmate at the Michigan State College of Agriculture and Mechanic Arts, the late Dean Charles Fuller Baker, Doctor Butterfield maintained a live interest in the progress of our institution up to almost the time of his death. His last visit to Los Baños was on February 17, 1931.

The University Council, at its meeting of July 25, approved to recommend the graduation of the following candidates for the degree of bachelor of science in agriculture: Antonio C. Alberto, Leona Atienza-Dacanay, Crispin K. Dacanay, and Onofre F. Martin.

The University of the Philippines Alumni Association, Laguna Chapter No. 1, is sponsoring the erection of a monument for the late Dean Baker, to be located in front of the Baker Memorial Hall. After the necessary arrangements can be completed, the Dean's many friends will be given a chance to subscribe voluntary contributions.

The student body organization of the College of Agriculture elected the following officers at its general meeting on July 2: president, Nelson Regalado; vice-president, Lorenzo Zialcita; secretary, Isidro S. Macaspac; treasurer, Pablo B. Agcanas; representative to the *Philippine Collegian,* Amando M. Dalisay; University student council representatives, Trinidad Q. Alconcel and Miguel Manresa, Jr.; adviser, Dr. F. M. Fronda.

The National Research Council is sponsoring a series of monthly scientific conferences, which began July 31, 1936, and will end January 22, 1937. Of the sixteen speakers scheduled, six are alumni of this College, namely, Dr. Vicente C. Aldaba, Dr. Feliciano Clara, Dr. Gonzalo Merino, Dr. F. O. Santos, Dr. L. B. Uichanco, and Dr. Deogracias Villadolid.

The following seniors of the College were elected associate members of the Society for the Advancement of Research at its meeting of July 16: José G. Luna (animal husbandry), José K. Demeterio (agricultural Chemistry), and Gavino B. Rotor, Jr. (agronomy).

Mr. Robert L. Usinger, an entomologist of the Hawaiian Sugar Planters' Association and well-known worker in Hemiptera, was at the College campus the latter part of July on his collecting and study trip from Guam. He spent a large part of his time going over the collection of Hemiptera in the Department of Entomology and securing material from Mt. Maquiling.

The Laguna Chapter No. 1 elected Professors Doroteo Soriano and L. B. Uichanco as its representatives in the U. P. Alumni Council.

The following papers were read at the meeting of the Los Baños Biological Club on July 30: Dr. Nicolas Galvez, "Plant-Food reserve in lowland and upland soils," and Dr. A. L. Teodoro and Mr. E. K. Ongsansoy, "Alcohol-gasoline mixtures as fuels for a high compression eight-cylinder automobile engine."

At a convocation in the College auditorium on July 30, Mr. Kenneth G. Murray, world traveller and lecturer, gave a stirring address on character and on dignity of labor. His talk was sponsored by the Los Baños Y. M. C. A.

A large delegation of Japanese students on a good-will trip to the Philippines visited the College on August 7.

The first faculty conference of the present academic year was held at the College Library on July 3. Prof. I. Panlasigui read a report on the May faculty conference in Baguio.

To fill the vacancy created by the death of Mr. A. V. San Pedro, Mr. Jesus de Guzman, of the Department of Soils, was transferred to the Department of Agricultural Education. Mr. De Guzman was relieved in the Department of Soils by the transfer of Mr. Jesus P. Mamisao from the Department of Agricultural Engineering. The resulting vacant position in the Department of Engineering lies in waiting for a qualified graduate.

PROFESSIONAL YARDSTICKS[1]

Public service in a democracy theoretically owes its existence to the will of the people. In a Utopian democratic state, where the mass of the citizens shall have attained such a level of education and discernment as would enable the voters properly to exercise the right of suffrage, no government position need be appointive.

In practice, however, a general extension of this method of selection of public servants in all the units of the governmental pattern would obviously give rise to impossible situations. A case in point is that represented by offices, bureaus, or similar public institutions the nature of whose work demands a personnel of scientists and technologists. It must be admitted that in science or in technology, beside the requirement of special individual aptitude, a good many years are needed in rigid preparation. From early youth, and even as an established worker, one must submit himself patiently to the exacting disciplines of his calling. He is constantly on trial, his record being continuously subjected to the sharp scrutiny of his colleagues. The jury that passes judgment on his work and his competence is unofficial and intangible, because its membership transcends institutional and national boundaries. No votes are cast at the polls, and there are no electors whose tickets might be tinted with partisanship or swayed by spell-binding protestations of adherence to a momentarily popular cause.

It is common knowledge that even in this relatively more advanced age, Filipino technical men are pitifully few. With the present program of economic expansion in this country, their number in many lines is certainly not equal to the task on hand. But one must recall the long centuries within historical times that produced hardly any Filipino scientist. The present small army of scientific workers had its inception scarcely four decades ago, and, even then, under the handicap of a rooted doubt as to the Filipino's capacity for scientific work. This, in conspiracy with current prejudice among the older generation of the Filipinos themselves against any profession but four, which were then considered the standard ones;

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[1] General contribution from the College of Agriculture No. 530.

namely, law, medicine, pharmacy, and priesthood. Considering all these difficulties, the wonder is that the country has produced even this small number of scientists.

In order that an undisturbed functioning of strategic scientific centers might be insured, an important desideratum would be a reasonable continuity and security of funds. This ideal arrangement has not always been found feasible, even in such relatively much wealthier countries as the United States. But, in cases where it has been put into practice, the results have invariably been for the best. It is heartening to note that some serious steps in this direction have been taken in the Philippines; as for instance, the assignment to the University of the Philippines of a ten-thousand-hectare forest reservation on the island of Basilan. It is too early to appraise the value of this land grant, although it is confidently expected that, when properly exploited, the future income will at least cover a sizable part of the pressing needs of this institution.

In general, however, we are dependent on the uncertainty of annual budgeting, which, under the circumstances, is to some extent premised upon the good-will of inscrutable bodies of men who have control over the expenditure of public funds. This is, of course, not intended as a complaint against existing conditions, but merely as a plain statement of fact. It seems a civic duty, however, to point out that there is one feature of the proposed salary-standardization law which, if allowed to prevail, might work to stultify the future development of science in the Philippines. The part referred to is that which would make the basic salary of the assemblymen, as fixed by the Constitution, the specific reference point for all salaries of government employees. One reassuring note is the stand which President Quezon is reported to have taken against the measure.

It does appear a disquieting symptom that the proposal should have emanated at all from quarters where one would naturally look up for guidance in selfless devotion to country. By implication, all the scientists in the employ of the government, unless they became first-class bureau directors, would be shoved automatically to a lower professional plane. The legislature admittedly counts on a number of men of superior natural qualification. A good proportion of the members are men that rank high in education and scholarship. Two or three are themselves scientists of standing. But position, of course, would not necessarily alter stature. The ultimate outcome of this artificial classification would be to place the legislature at an undue advantage later on in recruiting young men (and, eventually, young women also) of promise and ability. Save in very exceptional cases, it would take more than an inborn love of science for a potential intellectual giant among college undergraduates to aspire for a scientific career, with the years of hard and continuous grind it involves, knowing that from the start he would be doomed to labor under an inferiority complex. Small comfort would he derive from an American professor's recently published statement[2] that "long after many of their more publicized compatriots have been forgotten, the influence of these young scientists, representatives of a new order in the Far East, will be felt." In the end, our scientific institutions in the Philippines might serve merely as a haven of refuge for second-choice talents that would become scientists only because they could not make the grade for the legislature.

LEOPOLDO B. UICHANCO

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[2] Smith, Warren D. 1936. Leopoldo A. Faustino. Science 83: 152.

A bamboo bridge, College campus (J. B. Banzon photo.)

PALAY AND RICE PRICES [1]

JOSÉ E. VELMONTE
Of the Department of Agricultural Economics

WITH FIVE CHARTS

The sudden rise in prices of palay and rice [2] during the last half of 1935 to levels above the normal prices in the Philippines for the last five years has brought once more to the fore the rice problem. The high prices have brought about great hardships on the masses and, as a result, the government had to take some steps to help alleviate the situation. Because of a crisis in the rice situation various proposals have been advanced to have the government control the rice industry by one means or another as a permanent solution of the problem. The proposals ranged all the way from the most extreme measures as nationalizing the rice industry to more moderate plans as establishing a government stabilization corporation. The problem is so important that it becomes highly necessary to have as many of the facts as may be available about the rice industry so that intelligent opinion may be formed in an effort to seek a permanent solution to a problem that so vitally affects the welfare of all.

One of the aspects of the rice problem which has been little studied is the economic forces which control palay and rice prices. Outside of brief notes and general statements on prices which occasionally appear in the newspapers, there appears to be no literature dealing primarily with prices of palay and rice.

It is the aim of this paper to analyze the principal factors that govern palay and rice prices with the hope that it may help even in a small way to clarify some of the factors involved in the rice problem. A further object is to analyze the merits of the various proposals for government intervention in the rice industry.

Time and place

A trip to Nueva Ecija was made in May, 1935, during which time interviews were made with some palay producers, officials of the Liquetado Coöperative Marketing Association of Santo Domingo, and the principal rice millers of Cabanatuan, Santo Domingo and Gapan. The Bureau of Commerce's district commercial agent in Cabanatuan placed himself at the writer's disposal during his entire stay in Nueva Ecija. Several trips were made subsequently to the Bureau of Commerce and the Division of Statistics at Manila for conference with some of their officials and for some statistical data not available in the Department of Agricultural Economics of the College.

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[1] Experiment Station contribution No. 1135.

[2] *Palay* is rice with the hulls on. The word *rice* is applied to grain from which the hull, germ and bran layer have been removed.

MATERIALS

The statistical material on prices was obtained principally from the daily and weekly quotations issued by the Bureau of Commerce which are on file in the Department of Agricultural Economics. The period covered by this study is the five-year period from 1930 to 1934, inclusive. Statistical data for 1935 have also been included.

The writer gratefully acknowledges useful assistance rendered by the officials of the Bureau of Commerce, the Chief, Division of Statistics, Department of Agriculture and Commerce, and a number of rice growers and millers of Nueva Ecija, without whose combined help this work could not have been possible.

DISCUSSION

Importance of Nueva Ecija as the principal producer of palay

The province of Nueva Ecija is the largest producer of palay in the Philippines. Its normal crop during the last few years is about 8 to 9 million cavans [3] of palay which is about one fifth of the total produced in the Philippines. A very large portion of the crop of Nueva Ecija has to be prepared and moved to centers of population which produce little or no rice. Manila is the terminal market for rice, and rice receipts at Manila by railroad alone have averaged nearly 2 million sacks [4] annually of which over 1,200,000 sacks or about 60 per cent came from Nueva Ecija (table 4 and chart 4).

Nueva Ecija, therefore, occupies the central position in the growing and marketing of the country's staple food crop. Because of this importance of Nueva Ecija, the present discussion of palay and rice prices is primarily based on conditions prevailing in this premier rice producing province.

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[3] One cavan of palay weighs 44 kilograms.

[4] One sack of rice weighs 57 kilograms. One cavan of palay mills on the average into 28 kilograms of rice.

The rice miller

In order to be able to discuss prices, it will first be necessary to describe the position which the rice miller occupies in the marketing of palay and rice. The principal outlet for palay in Nueva Ecija is the rice miller. Asuncion (1932) demonstrated that over 40 per cent of the palay raised in Nueva Ecija was sold direct to rice mills at Cabanatuan. This fact must be supplemented by another in that in every important producing town in Nueva Ecija rice mills are the principal buyers of palay. The municipality of Gapan, for example, ranks next in importance to that of Cabanatuan as a marketing center for palay. Its rice mills handle the palay produced in the southern section of Nueva Ecija while those at Cabanatuan handle that produced in the central section of the province. The northern part is relatively not as important as a producer of palay.

Table 1 shows the distribution of rice mills in Nueva Ecija by towns. These mills with very few exceptions are operated in conjunction with the bonded rice warehouses of the province as shown in table 2. The rice miller is a warehouseman, because as a mill operator he needs a steady and sufficient volume of palay to keep his mill in operation. Table 2 shows that the great majority of warehousemen and millers in Nueva Ecija were Chinese middlemen. Since the rice mills constitute the primary outlet for palay in Nueva Ecija, any analysis of prices, in fact, marketing for that matter, must perforce deal primarily with the methods and practices of rice millers.

Prices received by farmers

Harvesting of palay in Nueva Ecija generally is begun in November and is completed in January. Threshing continues until April after which time, farmers generally haul their palay direct to the warehouses of millers. Except for some large rice growers, the farmer of Nueva Ecija does not have a warehouse for his palay. The rice millers provide facilities for warehousing and financing the greater part of harvested palay. The grower finds the arrangement convenient, if not fully satisfactory.

The total authorized capacity of bonded rice warehouses of Nueva Ecija for 1935 was nearly 1,200,000 cavans of palay (table 2). This would seem to appear that, after all, the millers' warehouses handled a relatively small portion of the province's normal crop of from 8 to 9 million cavans. This is more apparent than real. First of all, the so-called authorized capacity refers to the maximum amount which a public warehouseman can accept for deposit at any one time. Millers' warehouses could hold much more than their authorized capacities and they utilize their extra storage space for palay which they buy outright from growers and for which no public records need be kept. Second, the authorized capacity, referring as it does to the maximum quantity that may be deposited at any one time, does not give the total palay which enters the warehouses for deposit during one season. The mills are kept in operation as market conditions warrant and rice shipments are made regularly to Manila, being heaviest during the early months of the year (table 4), so that as fast as palay is run through the mills, additional palay may be deposited in the warehouses.

The farmer during the period of harvest and threshing needs financing. He may be so hard pressed for funds that as a last resort he sells his palay to the miller at very low prices. Chart 1 shows the seasonal variations of palay prices by months covering a period of five years, 1930-1934. It shows that normally, the price of palay falls from December, reaching its lowest level usually by February, March or April. This is, therefore, the poorest period to sell palay but growers who fail to get any credit accommodation have no other recourse than to sell at these ruinous prices.

Those who can get financing from millers or from the Philippine National Bank branch at Cabanatuan may be able to withhold sale by depositing their palay in the millers' warehouses in the expectation that they may be able to sell it later in the year at better prices. Referring again to chart 1 it may be seen that except in abnormal years, the prices of palay steadily improves from April reaching its peak in September or even as late as November just before the coming of the next crop.

Consolidated data on the business operations of 17 bonded rice warehouses representing most of the largest mills in Nueva Ecija (table 3) show that by May 1934 over 20 per cent of palay on deposit was already purchased by millers and by September, about 70 per cent. Reference to chart 1, however, will show that the course of prices in 1934 did not follow the normal seasonal trend of prices. The price of palay was relatively high in April and during the period only 15 per cent of palay on deposit was purchased by millers. When prices fell down during August, September, and October which was quite contrary to what is usually expected, about 44 per cent of all palay deposits were purchased by millers during this three-month period. It seems, therefore, that millers have extraordinary ability to know when to buy palay at prices most favorable to them. In years when palay prices follow the normal seasonal trend, buying by mills is heaviest during the first half of the year, thus enabling them to operate on a relatively large margin of profit with the advance in prices of rice and consequently of palay during the second half of the year. A case in point was the situation in 1935. It was not a normal year in the sense that prices rose to abnormal levels, but the course of prices followed in the main the seasonal trend.

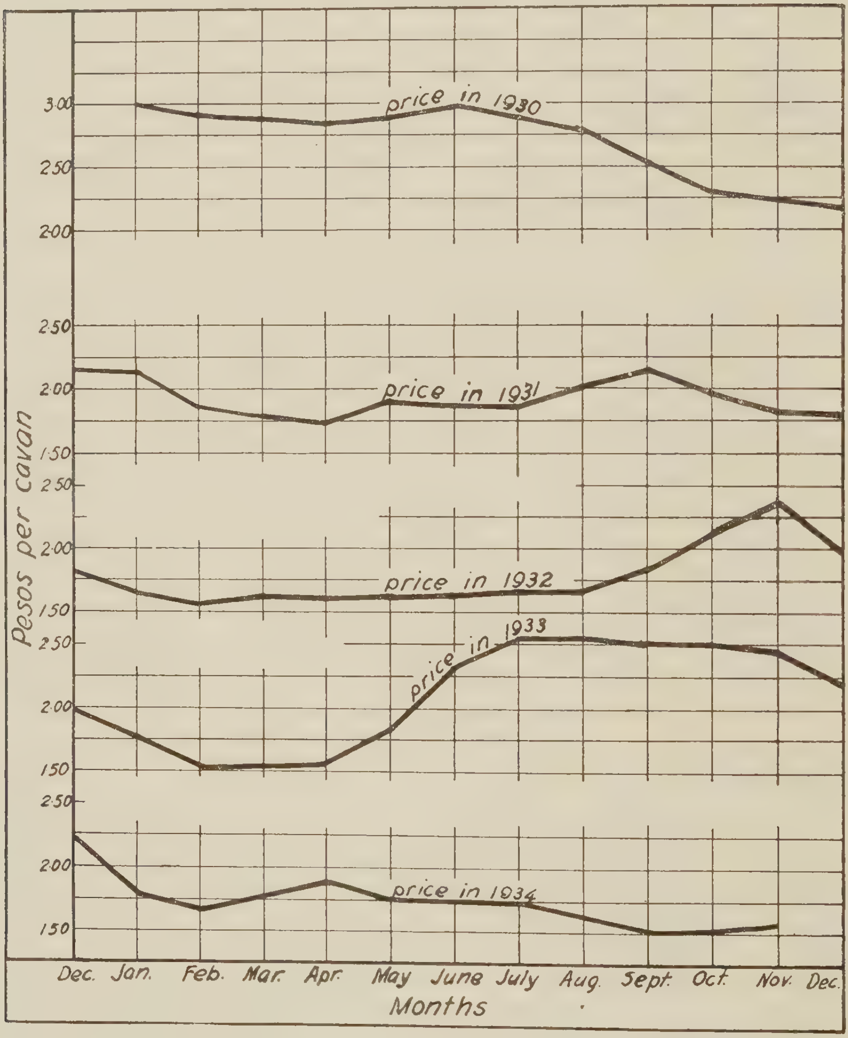

Chart 1.—Showing the seasonal variations in the prices of palay (*ordinarios*) at the Cabanatuan market, 1930-1934.

When prices began to soar in June, reaching a very high level in September and October, a survey by the Bureau of Commerce of stocks in Nueva Ecija, as reported in the *Philippines Herald* of September 21, showed that at the time when prices were most profitable, relatively little palay remained in the hands of farmers. This meant, therefore, that the farmers of Nueva Ecija as a group did not benefit very much from the high prices of rice and palay. The report gave the visible stocks as follows:

In the hands of merchants	379,458 sacks palay
In producers' warehouses	111,400 ” ”
Total	490,858

> Of the amount in the hands of merchants, only 80,000 sacks of palay remained unpurchased by them from depositors.

The amount in the hands of growers or still owned by them represented roughly about 40 per cent of the visible palay stocks.

Current palay prices reported in market reports for Cabanatuan are not the prices received by farmers. The prices of palay referred to in the foregoing discussion are not actually the prices received by farmers of Nueva Ecija. The explanation for this statement is found in the practices of the rice miller in his capacity as a public warehouseman. It must be remembered that the average miller is a warehouseman. He is so, primarily, so that he might have enough palay to keep his mill in operation. He has found in the business of storage an effective means of insuring for his mill a steady supply of palay soon after the harvesting season. He loans empty sacks to growers and in addition finances them. The farmers in turn obligate themselves to deposit their palay in the warehouse of the miller. The farmer finds in the arrangement a convenient, if not fully satisfactory, solution of his problems. The conditions of storage are made in such a way that withdrawals of deposits will prove most unprofitable to the depositor. The charges for palay deposits vary, but the following rates enforced by a large miller of Cabanatuan are typical:

Storage	1 centavo per month per sack
Insurance	1 ” ” ” ” ”
Premium on bond	1 ” ” ” ” ”
Shrinkage	1 kilogram per sack [5]

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[5] The charge for shrinkage will amount to about 4½ centavos per sack of 44 kilograms on the basis of quotations obtaining in May, 1935, when the writer was in Nueva Ecija.

These charges are levied should a depositor choose to withdraw his palay. These, however, are not charged should the farmer finally sell his palay to the warehouseman. This practice has engendered certain abuses in the marketing of palay. In practice, the palay grower who has a deposit in a miller's warehouse has hardly any opportunity to withdraw his palay when he finds another buyer. An examination of data on bonded rice warehouses (table 3) shows that withdrawals if any, constituted a very insignificant portion of palay deposits. The average depositor has most often received advances on his palay giving the warehouseman a lien on his product. While storage charges are apparently not charged when a depositor sells his palay to the warehouseman, these are more than made good by the practice of paying depositors a price lower by 10 or even as much as 15 centavos per sack than palay quotations in the Cabanatuan market. These prices, which are known locally as *liquidación* prices, are in practice the real buying prices of palay in Nueva Ecija. Palay quotations appearing in market reports refer to unencumbered palay or what is termed *"free parcels."* These prices, for the great majority of small producers, at least, are more fictitious than real. This is so, because the average farmer has no warehousing facilities and he has constant need for credit which only the miller in the great majority of cases can provide. Once his palay is deposited, purchase by the miller is on the basis of *liquidación* price. This discounted price is, therefore, the real price of palay from day to day which refers to the buying price of millers for palay on deposit in their warehouses. These prices vary in different warehouses.

The Philippine National Bank maintains an agency in Cabanatuan which serves not only Nueva Ecija but also the nearby provinces. Its loaning operations are, however, limited. During the first half of the year, when credit demands by farmers are usually heavy, figures for 1934 and 1935 showed that by about the end of May only between ₱400,000 to ₱500,000 was made available to palay growers. These amounts were loaned on the security of warehouse receipts and palay which are deposited in what are locally called *closed-door* warehouses, that is, private warehouses padlocked by the bank. These loans were made on the basis of ₱1.00 per cavan of palay on deposit. The amount of palay which these loans, therefore, represented was also between 400,000 to 500,00 cavans. It is obvious, therefore, that with such a large crop that is harvested in Nueva Ecija, the amount financed by the Philippine National Bank is small.

The bonded rice warehouse law[6] is a step made to protect the interests of the palay depositor. The lack of an adequate field force at the Bureau of Commerce, however, results in a very lax enforcement of the law. For example, it is frequently charged that the miller can easily utilize palay on deposit without the knowledge or authority of depositors. He may run it through his mill when opportunity for a good profit arises, thus enabling him to operate on a far greater scale than what his own capital would ordinarily permit. There were proofs that some millers did this before the passage of the warehouse law. Also it is freely expressed that some millers handle more palay than the amounts authorized under their licenses. These are more than merely conjectures because, with the lax enforcement of the law, the possibility and the temptation to contravene the law is open to an unscrupulous miller. The writer found, for example, when he was in Nueva Ecija in May, 1935 that the entries in the books of several warehousemen of Cabanatuan were months behind. Under the circumstances it was not possible to check the palay actually in storage against both the quantity on deposit and the authorized capacity. It was also observed that the practice of issuing temporary warehouse receipts, which served further to complicate the situation, was common. All these practices work to the detriment of depositors because these impair the liability of the warehouseman even when he is under bond.

Forces of monopoly are at work in helping determine the price of palay. There is ample justification for the statement that palay prices in Nueva Ecija are not wholly established by competition. The rice millers are the most important buyers of palay and they are relatively few in number. There was in 1935 a total of 42 rice mills in Nueva Ecija, 13 of which were in Cabanatuan; 10, in Gapan; and generally 1 for each of several other municipalities (table 1). While farmers were, therefore, engaged in destructive competition among themselves, in many municipalities at least, there seemed to be hardly any competition among buyers of palay. Even in such large centers as Cabanatuan and Gapan, competition was on a limited scale. Most of these mills were Chinese-owned, a number of which were under the same ownership. Their relatively small number conferred upon them bargaining powers much greater than those possessed by the farmers. The miller has usually a lien on palay deposited in his warehouse by virtue of loans granted to depositors.

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[6] Ninth Philippine Legislature, First Session, Act. No. 3893, approved November 16, 1931.

Under those conditions, farmers cease to have much influence in determining the price of their palay. Finally, there can hardly be any competition among millers because the large mills usually have their own separate clientele among growers, built up in the course of many years of business relation. As long as the greater part of the financing of the palay crop is made by the miller, this lack of competition in establishing the price of palay will continue.

Wholesale prices of rice in the Manila market

Rice millers ship their rice mostly to Manila as the terminal market. According to figures on railroad shipments of rice to Manila (table 4), nearly 1,200,000 sacks on the average are shipped annually from Nueva Ecija out of a total average shipment of about 2,000,000 sacks. Trucks, however, are increasingly becoming important as a means of transporting rice to Manila. The Bureau of Commerce estimated that monthly arrivals in Manila by all means of transportation average 250,000 sacks of rice or 3,000,000 sacks annually. It will mean, therefore, that about 1,000,000 sacks, or roughly one third of the total shipment come on trucks. It will be seen, therefore, from the foregoing that the railroad still furnishes the most important means of transporting rice to the central market.

Because of the importance of Manila as the terminal market for rice, it may be said that the forces of demand and supply over the entire country are brought there to a focus. The wholesale quotations in the Manila market, therefore, establish the prices of both rice and palay throughout the country.

A rice exchange has been in operation in Manila since 1922. It is an organization sponsored by the Philippine Chinese Rice Merchants Association. In some respects it functions like a produce exchange, although it lacks many of the principal features of modern produce exchanges. It maintains a trading floor where dealers in rice meet to transact business from day to day. So far as can be ascertained, the exchange does not deal in futures. Buying and selling are done by samples. The transactions are secret and the language used is Chinese. Government supervision is nominal and there appear to be no standard trading rules. It is said that a large portion of the rice received at Manila is sold through the exchange and, for this reason, it may be said that the price movement in the exchange from day to day reflects conditions in the rice trade (Abes 1925).

Charts 2a and 2b show the seasonal variations in the wholesale prices of rice in Manila from month to month for two five-year periods; namely, 1930-1934, and 1925-1929. It may be seen that in normal years rice prices fall steadily from December, reaching its lowest level by about February, March or as late as April. Prices steadily rise as the season advances, reaching their peak as early as September and as late as November. Then they fall again with

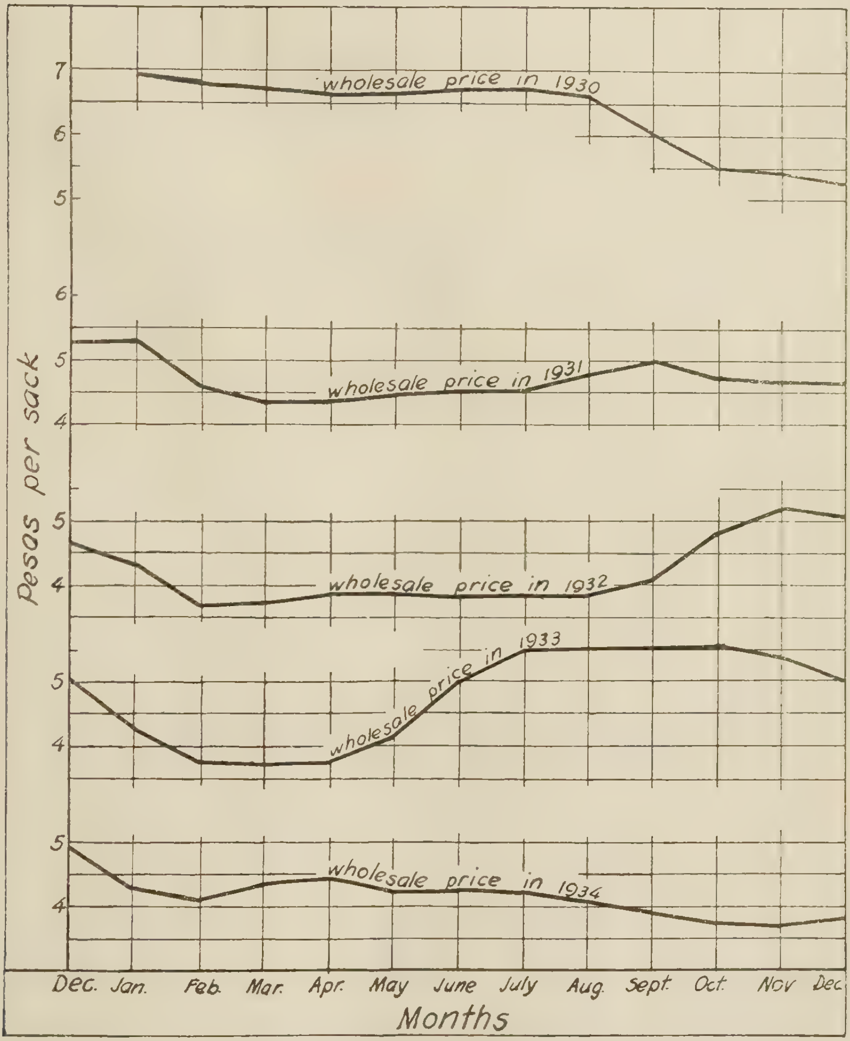

Chart 2a.—Showing the seasonal variations in the prices of rice (*macan*) at the Manila market, 1930-1934.

the appearance of the new crop. This was shown early in the paper to be exactly the normal seasonal trend of palay prices. Prices of palay (chart 1) and rice (charts 2a and 2b) have the tendency to fluctuate very greatly from year to year as may be seen in these

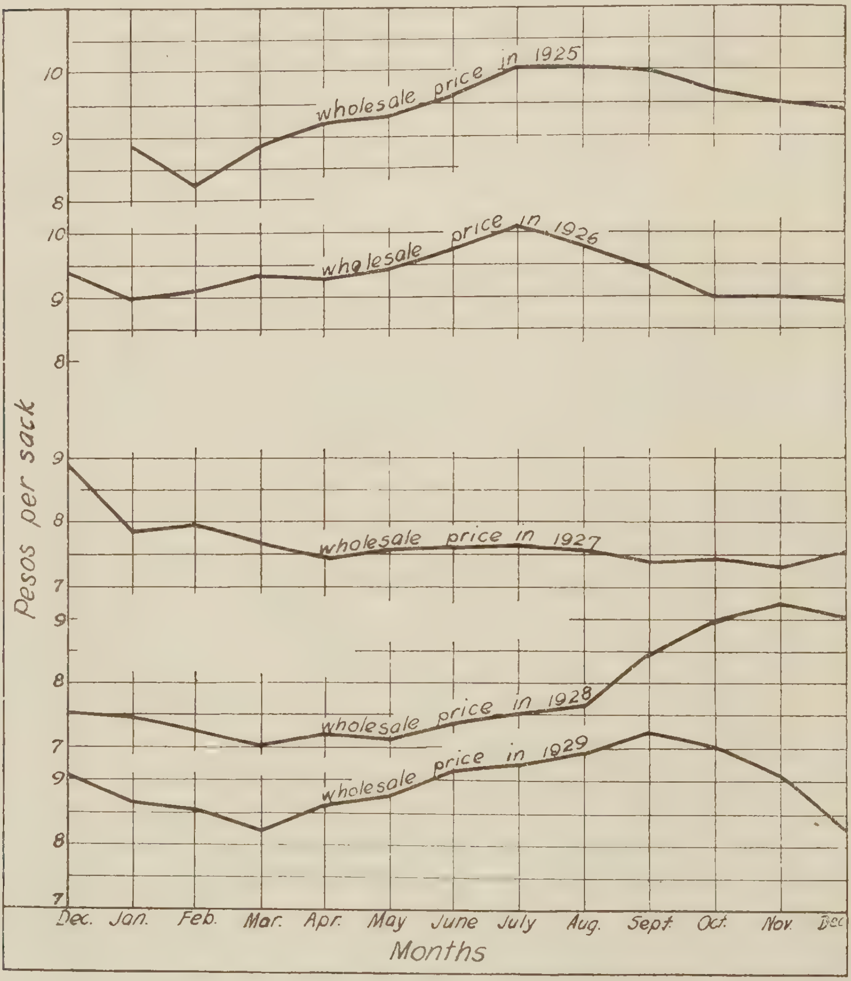

Chart 2b.—Showing the seasonal variations in the prices of rice (average of all grades) at the Manila market, 1925-1929.

charts. This is normally to be expected in the case of rice and largely for two basic economic reasons. First, changes in supply are not easily forseeable and even if they were, very little can be done about it. Second, the demand for rice is relatively inelastic.

These two factors bring about conditions which produce normally great fluctuations in prices.

Forces of competition help to determine palay and rice prices

Chart 3 attempts to show the relation between the wholesale price of rice in Manila and the price of palay at Cabanatuan for the last five-year period, 1930-1934 and for the greater part of 1935. The curves are made directly comparable by the use of a semi-logarithmic scale. It may be seen how closely palay prices at Cabanatuan followed wholesale prices of rice at Manila. Fluctuations in the wholesale prices of rice at Manila were faithfully reflected in the changes of palay prices at Cabanatuan. Even retail prices at Manila showed a very close correspondence to the wholesale prices, although normally retail prices in general tend to be little responsive to changes in wholesale prices.

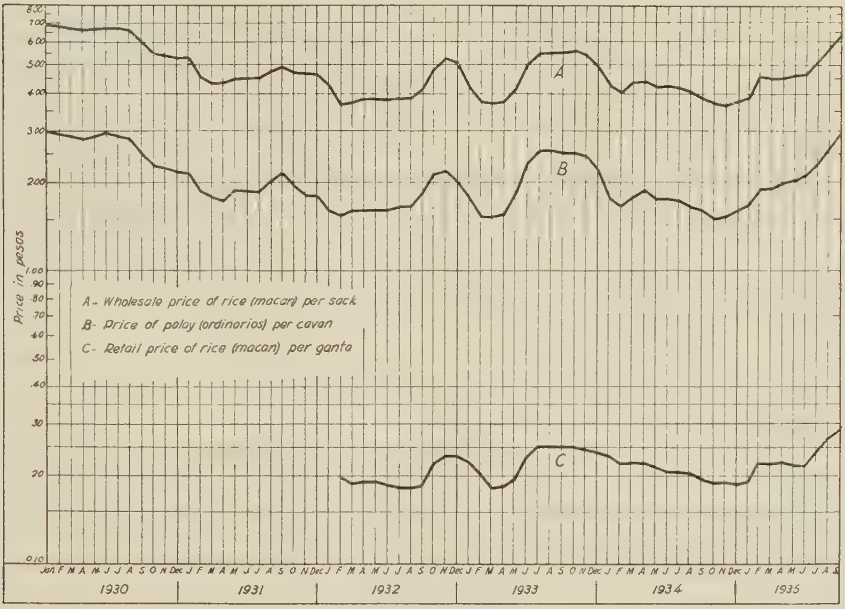

Chart 3.—Showing the relation between the wholesale and retail prices of rice (*macan*) at the Manila market and the price of palay (*ordinarios*) at the Cabanatuan market, 1930-1935.

It appears, therefore, that since there is a very close correspondence between the wholesale prices of rice at Manila and palay prices at Cabanatuan, millers in Nueva Ecija do not have absolute control of palay prices in their buying operations. This is an obvious conclusion and there is an element of truth to it, but one must weigh this against certain facts in the marketing of palay. First, palay quotations used in the comparison are not, as has been pointed out early in the paper, the true buying prices of palay in Nueva Ecija. Second, while it is true that with the improvement in the price of rice in the latter part of the year, palay price also rises in proportion, it cannot be concluded that palay farmers benefit from that rise. They do not, because it has been shown (table 3) that millers acquire most of the depositors' palay before the rise in prices. It is principally the millers who benefit from the rise in prices in the second half of the year. Of course, they are not to be blamed for this because in practicing storage as well as in undertaking financing, they are entitled to this rise in prices for the risk involved in the operations. Third, many wholesalers in Manila were financially interested in Nueva Ecija rice mills.

The operations of the rice exchange at Manila indicate that the forces of competition must have a part in price determination. While the rice exchange is not exactly identical with organized commodity markets elsewhere, its operation has tended to centralize trading operations in rice and made possible a greater play of the forces of supply and demand. It is true, of course, that in the absence of strict and standard rules the exchange might fail to curb unfair methods.

Chart 4 attempts to show the relation between receipts of rice at Manila and prices. The receipts of rice by railroad at Manila were averaged by month for the five year period, 1930-1934. These monthly averages were changed into relatives using the annual average as 100. The same was done for the wholesale prices (table 4). While in general, heavy receipts during the first six months of the year were associated with relatively low prices; and light receipts during the second half of the year, with relatively higher prices closer scrutiny reveals that at times prices in the Manila market moved apparently without regard to rice receipts. There are obvious limitations in this comparison. For example, receipts by railroad as was pointed out elsewhere in this paper, represented only about 66 per cent of the total rice receipts at Manila. Furthermore, receipts of rice in Manila from month to month may not accurately reflect supply because of ample storage facilities which are provided for rice at Manila. Despite these limitations, however, it appears that the rate of receipts of rice at Manila cannot be entirely ignored as a factor which helps to determine the wholesale prices of rice.

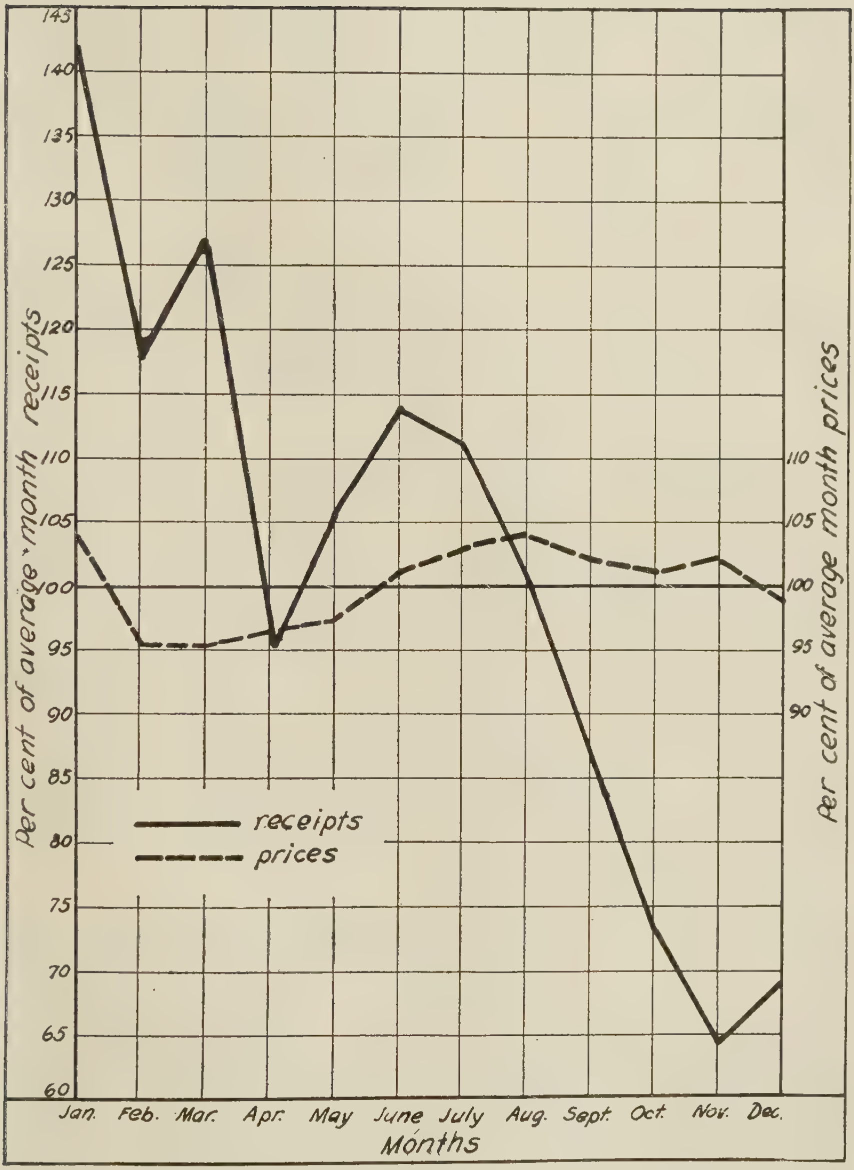

Chart 4.—Showing average rice receipts by railroad at Manila from Nueva Ecija and average wholesale prices of rice (*macan*) at the Manila market, 1930-1934. Annual average equals 100 per cent.

These facts contradict the opinion freely expressed by critics of the marketing system who are so quick and ready to charge Chinese middlemen in rice of absolute price manipulation. If prices are wholly manipulated, then they would move independently of the normal course which obtains under the workings of competition. Despite, therefore, many facts which show that Chinese millers and wholesalers have much to do in determining prices of palay and rice, there are also indications which show that competition of the market is not altogether absent.

Government intervention in the rice industry

The rise in prices of palay and rice to levels above normal during the second half of 1935 was made the immediate cause for proposals that the government should intervene in the rice industry. This move was not new because Chinese middlemen in rice have long been the object of extreme public criticism. Some of the ideas advanced were extremely radical and these found a common and for the moment, popular expression in what was termed nationalization of the rice industry. There was nothing definite about these ideas. Some were for government ownership of the industry; others were for government control of the distribution of the product; and some were for wresting the control of the trade by nationals from the hands of alien merchants. There were proposals that were less radical as, for example, the suggestion made that the government engage in some form of production control while leaving the industry in private hands. Finally, there were the more moderate measures suggested, as the establishment by the government of a stabilization corporation to influence the rate at which palay and rice are marketed so as to stabilize prices.

These proposals for agricultural reform are not new. They have been tried in many agricultural countries in the control of the production of various staple articles. The most extreme type of control is found in socialist Russia where farms are operated as collectives and as state-owned enterprises. They have not been free from serious obstacles and this socialization of agriculture is totally abhorrent to a democratic state. The most noteworthy example and one which is most familiar to the Philippines of government production control was the A.A.A. in the United States. It attempted to regulate the number of persons engaged in certain agricultural industries, the area devoted to each crop, and the marketing of the products in an effort to improve agricultural prices. It had been a costly experiment and it had met most bitter criticism from many quarters and even disillusioned many who were first its ardent supporters. Finally, there have been many agencies tried in several countries to stabilize prices of staple articles by some form of regulation of the flow of these products to market. Among some of the examples were the coffee valorization scheme of Brazil, established as early as 1906; the Stevenson rubber control plan for the Federated Malay States, in 1922; the New Zealand dairy export control plan of 1923; the Cuban cooperative export agency of 1929; the Federal Farm Board of the United States in 1929; and the Japanese government control of rice which started in 1921. Space will not permit an appraisal of each of these plans. The experiences of the Federal Farm Board, however, are of timely interest. The apparent identity of present plans to stabilize palay and rice prices to the Japanese control scheme merits a brief mention of the later in the following discussion.

These several agencies for stabilization of agricultural prices assume importance for the Philippines today in view of the formation of the Rice and Corn Corporation as a subsidiary of the National Development Company during the first week of April, 1936. This corporation was recommended by the government Rice Commission in its report submitted to the President in the early part of March. The commission outlined the proposed activities of the corporation [7] principally as follows:

> (1) ....to engage in the business of buying and selling palay and rice.
>
> (a) In order to maintain prices at a level profitable to producers, this corporation will buy palay or rice at a price to be determined from time to time sufficient to cover average production cost plus a reasonable profit; and
>
> (b) To prevent an excessive rise in the price of the cereal, the corporation will sell palay or rice at prices reasonable to the consumer, considering general economic conditions and consumers' purchasing power, and when necessary this corporation will import rice, free of duty, to be sold through regular trade channels.

It is evident from the foregoing that the corporation is to attempt to stabilize prices primarily by undertaking to buy and sell palay and rice as conditions of the market warrant. In view of the shortage of the 1935-1936 rice crop, the corporation centered its activities for the present year at least in the importation of rice free of duty as a relief agency under Act No. 4198. Rice thus imported is now being sold to dealers at a uniform price per sack of ₱6.24 c. i. f., accessible point of destination. The dealers are to sell this rice at prices not exceeding ₱6.44 per sack and ₱0.28 per ganta. Municipal treasurers may still continue to handle such rice and, unlike the practice last year, this rice may now be sold to any purchaser. It is too early to express any judgment as to the effect of this measure on the prices of rice in the market. So long as the activities of the corporation are confined to importations of rice free of duty, there appears to be no likelihood that it will ever meet financial reverses. Under present market conditions, the corporation is making fairly large profits because of its ability to import rice free of duty [8] and this fact makes it well nigh impossible for any private merchant to handle imported rice in competition.

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[7] Report of the Rice Commission, *The Tribune*, March 8, 1936.

The program of activities of the corporation as envisioned by the Rice Commission is, however, much broader than merely the importation of duty-free rice. When the Philippine rice production returns to normal, the problems of stabilization will appear to be much more complex. There are, further, indications that the corporation might extend its activities next year so as to bring its services to the palay producers. On the basis of the entire program of activities of the corporation as outlined by the Rice Commission, it is vitally necessary to take a long range view so that a correct appraisal of their probable consequences may be made. The following discussion is an attempt to that end.

It is evident from the program of activities of the corporation that it will buy and sell palay and rice so as to stabilize prices at a level which, while profitable to producers, will prove reasonable to consumers. The determination of a minimum buying price is identical to the Japanese plan which sets a minimum price equivalent to cost of production at which the government is authorized to purchase in any amount. Unlike the Japanese plan, however, the commission has not fixed a maximum price at which the corporation may begin to sell its holdings. When prices in the opinion of the corporation become "excessive or prohibitive", then it may sell its holdings "at a price that will prevent a further rise in prices."

The objective of correcting extreme fluctuations of palay and rice prices is an attractive and worthy one. The commission apparently is of the belief that violent fluctuations in the prices of palay and rice may be greatly minimized by controlling the rate at which these commodities are marketed. This control is to be effected by the corporation buying palay and rice during periods of very low prices and selling them during times when prices rise to unduly high levels. An initial capital of ₱2,000,000 is being made available to finance its operations.

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[8] The present duty on foreign rice is ₱5.00 per 100 kgms.

While in theory stabilization operations, as described above, appear simple and essentially sound, in practice these operations bring in their train a number of perplexing problems. There are two types of price fluctuations of palay and rice, and in fact of all farm products for that matter, namely, the intra-seasonal and the inter-seasonal. Intra-seasonal fluctuations refer to variations in prices during one crop year which are generally low during the crop harvesting season and high as the season advances. These variations in prices are essentially due to the fact that the flow of these products to market is often ill-adjusted to current demand and to warehousing facilities at the terminal markets. Inter-seasonal fluctuations in prices refer to those brought about by the variations in the annual yield of crops.

So long as the Philippine rice crop does not greatly exceed or is below consumption requirements, stabilization operations will appear to be largely the buying and selling of palay and rice to reduce intra-seasonal fluctuations. This type of operations appears to be relatively less risky as compared with inter-seasonal operations because there will be less likelihood of the corporation carrying over a surplus to the crop year following. There are, nevertheless, many obstacles to be overcome to insure a measure of success. It is difficult, for example, to be certain that operations may be confined to intra-seasonal stabilization. The danger is always present that intra-seasonal operations might be converted by force of circumstances into inter-seasonal transactions. The brief experience of the Federal Farm Board is illuminating. In the fall of 1929, in view of a short world wheat crop, the Board felt justified in engaging in intra-seasonal stabilization operations. Accordingly it attempted to support a market price of wheat which later events proved to be unduly high. It found itself, therefore, at the end of the 1929-1930 crop season in possession of 60 million bushels of wheat largely because of an unforeseen fall in European demand. It had to hold this over for the next crop year. These operations which originally were intra-seasonal were transformed by unforeseen conditions of the wheat market into an inter-seasonal operation on a large scale. By April 1931 the Board's holdings reached 200 million bushels. The problem of financing a carry-over from one crop year to another is indeed a difficult one. The Board found that it could not sell its wheat carried over from the previous crop year in competition with the new crop as it would have met great opposition by the very farmers whom it aimed to benefit. Consequently, these stocks proved to be unsalable and the Board had to shoulder the loss.[9]

Another obstacle to be met lies in the difficulty of determining when to undertake intra-seasonal stabilization operations and at what prices should the market be supported. Purchases and sales at wrong times, or in quantities too large than warranted might even increase fluctuations in prices rather than decrease them. Professor Slichter, of Harvard University, speaking of the Federal Farm Board served this warning:

> "The brief experience of the Federal Farm Board indicates plainly how difficult is the technical problem of deciding when to undertake stabilization operations and how easy it is for highly competent men to make an erroneous decision. The Farm Board is composed of men of ability and has had the assistance of a competent technical staff." [10]

The corporation in the words of the commission should support a price "profitable to producers" and "reasonable to the consumer"; on the one hand "sufficient to cover average production cost plus reasonable profits" and on the other hand consistent "with consumer purchasing power." To support such a price as is being contemplated would mean that accurate statistical information on the rice industry should be available. Indeed one important limiting factor for the success of the corporation will likely be the lack of statistics on the industry. An accurate crop-reporting system will indeed be necessary. Stocks of palay and rice at production and distribution centers as well as crop movement should at all times be available. Consumption requirements should be known. Data on costs of production are essential. Production and price trends must be analyzed with care and the crop and trade situation in the Orient must also be taken into consideration. All these needed data are almost totally unavailable today and the corporation will grope blindly and unintelligently without the benefit of competent crop and trade information services. The idea of maintaining a price based on average cost of production, plus a reasonable profit, appears questionable. If this were attempted it might penalize many producers whose costs are near the margin but whose output will be necessary to bring the total production at least equal to domestic requirements. It would seem more workable to support a price near or equal to marginal costs.

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[9] SLICHTER, SUMNER H. Modern Economic Society. 1932, xii +909 p. New York: Henry Holt and Company, Chapter XIX.

[10] *Ibid.*, p. 443.

The two million pesos provided to finance the operations of the corporation appear small. Even on the basis of estimated annual shipments of rice to Manila from the Central Plain provinces which is placed at about 3 million sacks, this fund, if used entirely in rice operations during one season, would mean at current prices of *macan* rice only about 300,000 sacks. It appears doubtful if this quantity that the corporation might buy or sell should prove sufficient to affect substantially prices.

Evidence is ample that stabilization operations, as tried in many countries, have invariably occasioned financial losses to the government.[11] Especially is this situation imminent when production of palay goes beyond domestic requirements. In years when crops prove unusually good, the corporation will be forced by circumstances to undertake inter-seasonal operations. Surpluses will have to be held and once withdrawn from the market during one year may not be sold at all unless extreme crop shortages occur subsequently. Except in years of great crop shortage and these do not occur frequently and neither would their frequency be welcome, the corporation will not be able to sell its carryover without destructively competing with farmers and processors handling the current crop. The experience in other countries is that it is not possible to do so without depressing the market and antagonizing the farmers. That production of palay may in due course rise to a point far above consumption requirements appears inevitable. The very activities of the corporation in maintaining a profitable level of prices will prove a powerful incentive to that end. The Japanese rice control was started in 1921 with the immediate goal of attaining a position of self-sufficiency. The maintenance of relatively stable and profitable prices together with restrictions of rice importation accomplished the desired result in a few years.

A profitable level of prices, if maintained at all, will further tend to destroy any desire on the part of the farmers to reduce acreage which, in the absence of control, will normally operate in the face of large crops. Finally, the prospect of further restrictions on our exports to the United States will eventually tend to increase the acreage planted to rice.

The commission of course has, in its report, realized the danger and the contingency of production rising very far above domestic requirements. The remedies suggested as financing exports and controlling the opening of new lands to rice may, however, prove unequal to the problem. Some form of production control might ultimately result from the activities of the corporation in holding a large carryover.

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[11] Tobata reported that the Japanese rice control system has lost a total of 185 million yens in twelve years of operation from 1921 to 1932. The only year in which profits were realized was the first year, namely, 1921.

It is not, however, implied that just because stabilization operations may in all probability lead to financial loss on the part of the corporation that it would be unjustified for the government to undertake it. Public welfare will obviously be promoted should the corporation succeed in bringing about more stable prices. Farmers will benefit from more stable incomes, assuming that more stable prices will mean more stable incomes; industries that sell to farmers will likewise benefit from more stable purchasing power; and finally consumers will also be protected from the rise of prices to exorbitant levels. From the standpoint of community welfare, therefore, stabilization operations may find justification so long as the good they confer can outweigh possible financial losses.

The field of government activities in connection with the rice problem need not, however, center unduly in stabilization operations. It would seem that the same objectives may be accomplished with less financial risk and along more conservative lines. A simple solution may be found in making the rice tariff flexible so that, when a shortage impends, it may be reduced or done away with altogether and when the emergency has passed, or when there is overproduction, the tariff may once more be raised to the previous level. The government might even undertake the importation of rice as it has been doing now in the face of an acute crop shortage. The system of distribution should, however, be perfected so as to have the imported rice reach the public easily. This will tend to break the hold of merchants on the price of rice. The practice followed last year in distributing government rice through municipal treasurers proved defective and the limitation that such rice could only be sold to distressed families did not materially help in easing prices in the Manila market. This was to be expected because government rice was not made available to all consumers, hence it did not really compete with rice handled by merchants through the regular trade channels.

SUMMARY

1. An attempt has been made to discuss the principal forces that determine palay and rice prices based on conditions prevailing in Nueva Ecija which is the premier rice producing province.

2. The discussion centers in the relation between the prices of palay received by farmers of Nueva Ecija and the wholesale prices of rice in the Manila market. It is shown that market quotations for palay in Cabanatuan are not the real buying prices of millers who control the trade. A discounted price, known as *liquidación* price, is actually the buying price of palay in Nueva Ecija. This is true because the average farmer lacks warehousing and credit facilities and he has, therefore, to deposit his palay in the miller's warehouse. The miller has accordingly a lien on palay on deposit and for that reason, the farmer ceases to be an important factor in determining the price of his palay. While in theory the farmer's palay is in the miller's warehouse for storage, in practice, the miller eventually buys it at *liquidación* prices which are far below the current market quotations. These prices vary in different warehouses.

3. The facts about the marketing of palay and rice in so far as they relate to prices are exceedingly complex. It is shown in this paper that forces of monopoly appear to be at work in determining prices of palay and rice. On the other hand, there are certain facts which show that competition doubtless plays also its part. Palay quotations, for example, move in harmony with wholesale prices of rice, indicating that prices at Nueva Ecija do not seem to be wholly within the control of millers. That wholesale prices of rice in Manila appear to be also influenced by competition is shown by the operations of a rice exchange and further by an apparent relation between receipts of rice by railroad at Manila and prices. Despite, therefore, many facts which show that Chinese millers and wholesalers have much to do in determining prices of palay and rice, there are also positive indications which show that competition of the market is not altogether absent.

4. Government intervention in the rice industry by means of the organization of a Rice and Corn Corporation involves a number of problems. The analysis of the proposed activities of this corporation is based on the report of the Government Rice Commission. While in theory stabilization operations as are being contemplated appear simple and essentially sound, in practice, these operations are fraught with difficult problems. For example, operations cannot easily be confined to intra-seasonal transactions because rice production will inevitably rise far above domestic requirements. Once this obtains, inter-seasonal operations, involving the handling of large carryovers, will most likely lead to financial loss by the stabilization corporation. To help prevent huge losses such operations might finally lead to some form of production control.

5. Another obstacle to be met with lies in the difficulty of determining when to undertake intra-seasonal operations and at what prices should the market be supported.

6. The objective of correcting extreme fluctuations in prices and their maintenance at relatively profitable levels is a worthy one. Difficulties, however, will at once appear in that it will tend to serve as a powerful stimulus for farmers to increase production which will tend to rise far above consumption requirements.

7. Stabilization operations, however, may find justification in its objectives of alleviating suffering and promoting public welfare. After all, the government considers it to be its duty to embark in undertakings which while necessary or good may be so risky that private capital will not likely seek investment.

8. The field of government activities in solving the rice problem needs not, however, center unduly in stabilization operations. It would seem that the same objectives may be accomplished with less financial risk and along more conservative lines. A simple solution may be found in making the rice tariff flexible so as to make the available rice supply more responsive to changing demand. Also, importation of rice by the government may be undertaken to meet an emergency but, unlike the practice last year, the distribution of this rice should be improved so that it may enter into competition with rice handled by merchants through the regular trade channels.

9. This study does not presume to fully cover the field of palay and rice prices. The statistical material covers a relatively short period. Much data are lacking and some of those used were found to have shortcomings. In the meantime further study may be expected to yield additional information and more definite conclusions. The Rice and Corn Corporation is at present engaged solely on the importation of rice free of duty to relieve a crop shortage. What it may further do to accomplish its objectives as outlined by the Rice Commission remains to be seen. The program of activities of the corporation as envisioned by the Rice Commission is, however, so broad and fraught with consequences that it is vitally necessary to take a long-range view in an effort to find a correct solution of the rice problem.

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TABLE 1

Showing rice mills in Nueva Ecija
1935

TOWN	NUMBER OF RICE MILLS
Cabanatuan	13
Cabiao	3
Cuyapo	1
Gapan	10
Guimba	1
Jaen	1
Muñoz	1
Peñaranda	1
San Antonio	3
San Isidro	1
San Jose	2
Santa Rosa	3
Santo Domingo	1
Talavera	1
Total	42

TABLE 2

Showing bonded rice warehouses of Nueva Ecija, 1935.

NAME OF WAREHOUSEMAN	NATIONALITY	PLACE OF BUSINESS	AUTHORIZED CAPACITY	BOND FURNISHED [2]
			cavans palay	*pesos*
1. Olimpio Cajucum	Chinese	Cabanatuan	8,000	6,000
2. Cheng Siong Lam & Co.	"	"	65,000	[3]
3. Ching Lin & Co.	"	"	65,000	40,000
4. Felix Daluz	Filipino	"	20,000	12,000
5. Enrique Gatbonton	"	"	15,000	15,600
6. Kwong Ah Phoy & Co., Inc.	Chinese	"	60,000	24,000
7. Magdalena de Lapuz ..	Filipino	"	70,000	62,000 [4]
8. M. Chua Kay & Co. ...	Chinese	"	20,000	45,375 [5]
9. Joaquin de Ramoso ...	Filipino	"	15,000	20,000
10. Meliton Rigor	Filipino	"	20,000	12,000
11. Siy Cong Bieng & Co., Inc.	Chinese	"	30,000	18,000 [6]
12. Sy G. Chaco & Co. ...	"	"	40,000	30,000
13. Tan Sio Co. S en C. ..	"	"	23,000	18,000 [6]
14. Lorenzo Veneracion ...	Filipino	"	60,000	55,000 [7]
15. Demetrio Berin	"	Peñaranda	4,500	2,250
16. Luis Borja	"	Gapan	100,000	75,938
17. Francisco de Borja ...	"	"	20,000	[8]
18. Cheng Siong Lam & Co.	Chinese	"	15,000	[3]
19. Cheng Siong Lam & Co.	"	" (Sn. Nicolas)	80,000	110,730 [3]
20. Baltazara Dycueco	Filipino	"	12,000	9,910
21. M. Chua Kay & Co. ..	Chinese	" (Baluarte & Sn. Nicolas)	35,000	[5]
22. Ng Si	"	" (Baluarte)	2,000	2,200
23. Rosario Tan Naval	"	"	20,000	[9]
24. Tan Sen Guan & Co., Inc.	Chinese	"	30,000	30,000 [6]
25. Francisco de Borja	Filipino	Sta. Rosa	30,000	50,000 [8]
26. Co Leco & Co.[1]	Chinese	"	120,000	120,000
27. Hermogena Romero ..	Filipino	"	13,300	8,000
28. Chan Kian Co. S. en C.	Chinese	Cuyapo	35,000	30,000 [6]
29. Tecla Chichioco & Sons	Filipino	Talavera	10,000	6,000
30. Jewel Rice Mill	"	San José	20,000	30,000
31. San José Rice Mill, Inc.	Chinese	"	20,000	16,500 [6]
32. Gregorio A. Paez	Filipino	San Antonio	3,000	2,400 [6]
33. Miguel Santiago	"	"	2,000	1,200
34. Venancio Santiago	"	"	1,200	1,000
35. Magdalena Gallardo ...	Filipino	Jaen	3,500	2,500
36. Julita Relucio	"	Cabiao	8,000	7,445
37. Rosario Tan Naval ...	Chinese	"	20,000	25,000 [9]
38. Purificacion Ureta	Filipino	"	1,200	1,400
39. Tio Lan Rice Mill	Chinese	Muñoz	10,000	9,000
40. Tin Tho	"	Guimba	36,000	30,000 [6]
41. G. Trinidad	Filipino	San Isidro	5,000	5,000
Totals			1,187,700	934,448

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[1] Burned down, June, 1935.

[2] Unless otherwise stated, these bonds are first mortgages on real estate.

[3] Consolidated bond for Nos. 2 and 19.

[4] Real estate first mortgage ₱42,000; 2nd mort. ₱20,000.

[5] Consolidated bond furnished by Visayan Surety Co. for Nos. 8 and 21.

[6] Bond furnished by a surety company.

[7] Real estate 1st. mort. ₱30,000; 2nd. mort. ₱25,000.

[8] Consolidated bond for Nos. 17 and 25.

[9] Consolidated bond for Nos. 23 and 37.

TABLE 3

Showing the business operations of 17 bonded rice warehouses of Nueva Ecija by months, 1934

MONTH	DEPOSITS	CUMULATIVE PERCENTAGE	WITHDRAWALS	PER CENT OF DEPOSITS	PURCHASED BY WAREHOUSEMEN	CUMULATIVE PERCENTAGE OF DEPOSITS
	sacks		*sacks*		*sacks*	
January ...	279,946	29.2	2,375		4,147	0.4
February ..	351,231	65.8	8,148		48,302	5.5
March	196,635	86.3	7,474		47,588	10.4
April	63,585	93.0	2,354		47,065	15.3
May	50,966	98.3	9,168		47,638	20.3
June	9,864	99.3	4,237		62,584	26.8
July	3,025	99.6	1,197		101,415	37.4
August	966	99.7	3,564		142,826	52.3
September .	2,641	100.0	6,151		169,016	69.9
October ...	—	—	6,004		108,185	81.2
November .	—	—	2,163		62,831	87.7
December ..	—	—	—		8,283	88.6
Totals ..	958,859	100.0	52,835	5.5	849,880	88.6

TABLE 4

Showing average rice receipts by railroad at Manila and average wholesale prices of rice at Manila by months, during the 5-year period, 1930-1934

MONTH	AVERAGE TOTAL RECEIPTS		AVERAGE RECEIPTS FROM NUEVA ECIJA		AVERAGE WHOLESALE MANILA PRICES	
	Average total receipts	Per cent of av. month receipts	Average receipts	Per cent of av. month receipts	Average monthly prices	Per cent of av. month prices
	sacks		*sacks*		*pesos per sack*	
January ..	219,990	132	146,259	142	4.99	104
February .	200,723	121	120,203	117	4.56	95
March	203,648	123	129,354	126	4.56	95
April	157,813	95	97,969	95	4.58	96
May	171,872	103	109,153	106	4.65	97
June	184,148	111	117,195	114	4.84	101
July	187,040	113	114,406	111	4.94	103
August ...	177,760	107	103,171	100	4.95	104
September.	142,789	86	86,355	84	4.88	102
October ..	123,901	75	75,589	73	4.84	101
November .	104,869	63	65,722	64	4.87	102
December .	118,707	71	71,119	69	4.72	99
Total	1,993,260	—	1,236,495	—	—	—
Average ..	166,105	100	103,041	100	4.78	100

TABLE 5

Showing average monthly prices of palay (ordinarios) per cavan at the Cabanatuan market, 1930–1935 [a]

MONTH	1930	1931	1932	1933	1934	1935
	pesos	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*
Averages .	2.69	1.89	1.76	2.10	1.68	—
January .	2.98	2.13	1.62	1.76	1.78	1.67
February .	2.91	1.86	1.54	1.53	1.66	1.88
March	2.88	1.77	1.60	1.51	1.78	1.90
April	2.83	1.72	1.60	1.55	1.88	1.98
May	2.87	1.87	1.60	1.82	1.75	2.06
June	2.96	1.86	1.61	2.31	1.75	2.10
July	2.86	1.85	1.65	2.55	1.73	2.33
August ...	2.83	2.02	1.65	2.55	1.65	2.61
September.	2.50	2.15	1.83	2.50	1.61	2.94
October ..	2.27	1.95	2.13	2.51	1.51	[b]
November .	2.24	1.81	2.38	2.45	1.52	—
December .	2.15	1.79	1.99	2.20	1.59	—

[a] These prices were computed from weekly market reports published by the Bureau of Commerce, Manila. Some figures were not complete.

[b] Not available at the time of the work.

TABLE 6

Showing average monthly wholesale prices of rice (macan) per sack at the Manila market, 1930–1935 [a]

MONTH	1930	1931	1932	1933	1934	1935
	pesos	*pesos*	*pesos*	*pesos*	*pesos*	*pesos*
Averages .	6.31	4.64	4.17	4.73	4.06	—
January ..	6.93	5.29	4.28	4.21	4.25	3.88
February .	6.77	4.55	3.65	3.73	4.08	4.60
March	6.67	4.35	3.73	3.71	4.36	4.50
April	6.58	4.35	3.84	3.75	4.39	4.51
May	6.64	4.49	3.85	4.11	4.18	4.63
June	6.70	4.50	3.81	4.98	4.23	4.69
July	6.71	4.51	3.85	5.47	4.19	5.19
August ...	6.58	4.77	3.85	5.50	4.06	5.72
September.	6.01	4.91	4.13	5.51	3.85	6.38
October ..	5.47	4.72	4.81	5.55	3.69	[b]
November .	5.42	4.65	5.23	5.37	3.66	—
December .	5.25	5.64	5.03	4.93	3.78	—

[a] These prices were computed from weekly reports published by the Bureau of Commerce, Manila. Some figures were not complete.

[b] Prices for the last three months of 1935 were not available when the work was made.

TABLE 7

Showing average monthly retail prices of rice (macan) per ganta at the Manila market, 1932–1935 [a]

MONTH	1932	1933	1934	1935
	Centavos			
Averages	18.1	22.4	20.6	—
January	[b]	22.1	23.1	19.1
February	19.8	20.3	21.7	22.2
March	18.6	18.0	22.0	21.9
April	19.0	18.4	22.0	22.0
May	19.0	19.4	21.3	21.5
June	18.4	22.8	20.5	21.5
July	18.0	25.0	20.5	24.1
August	18.0	25.0	20.3	26.9
September	18.4	25.0	19.3	28.8
October	21.9	25.0	19.0	[b]
November	23.2	24.5	19.0	—
December	23.2	24.0	18.6	—

[a] These prices were computed from daily market reports of the Bureau of Commerce, Manila. Some figures were not complete. Data for 1930 and 1931 were not available.

[b] Not available at the time of the work.

STUDIES ON THE STORAGE-TEMPERATURE REQUIREMENTS OF LANZONES (LANSIUM DOMESTICUM CORREA)[1]

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WITH ONE TEXT FIGURE AND NINE CHARTS

Unfortunately for producers and consumers alike, the lanzon is a perishable fruit, unusually so. Under ordinary conditions it does not remain in a good marketable condition for more than four days. Furthermore, it is a short season crop, the greater part of the product going to the market within less than a month. Consequently, the limited supply at the beginning of the season and the glutting of the market at the height causes a fluctuation in the price of the fruit, of from ₱1.50 to ₱0.20 per hundred. This situation is obviously unsatisfactory and suggests the necessity of studying means of prolonging the life of the fruit. Successful storage will prolong the lanzon season, keep the price more stable and enable the growers to export to nearby countries any excess production. The most modern method of storing fruit, that of cold storage, may be a possible means of lengthening the life of lanzones.

The writer was not able to find any published work on the cold-storage of lanzones. Works on the old storage of other fruit which may have a relation to the present study are cited elsewhere in this paper.

The objects of the present work are (*a*) to determine the freezing point of the juice of ripe lanzon; (*b*) to determine the optimum storage temperature for the fruit; (*c*) to measure the rate of respiration of green, turning, and ripe fruit at various temperatures; (*d*) to study the influence of maturity on catalase activity; and (*e*) to determine the more important chemical changes in the fruit while in storage at different temperatures.

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[1] Experiment Station contribution No. 1136. With the exception of table 5, the data presented in this paper were taken from the thesis presented in 1932 by the author to the University Graduate Committee, University of the Philippines, in partial fulfillment of the requirements for the degree of Master of Science. A part of this paper was read before the Los Baños Biological Club in September, 1932. This article is published posthumously.

[2] The author gratefully acknowledges his indebtedness to Dr. Leon G. Gonzalez, of the Department of Agronomy, under whom this work was undertaken, for his valuable suggestions in the planning of the experiments and for criticisms in the preparation of the manuscript. Thanks are also due the staff of the Department of Agricultural Chemistry for generously furnishing the space, apparatus and reagents needed in the analytical work.

These studies were conducted in the pomology division of the Department of Agronomy, College of Agriculture, University of the Philippines. The period was divided into two parts. The first period extended from July, 1930, to June, 1931, and was devoted to the setting up of the apparatus called for in the experiments and to learning the technique of running them. This included preliminary work on determination of freezing point, catalase activity and respiration. The second part was from July, 1931, to November, 1931, and from September to October, 1932, during which the actual studies on lanzones here reported were made.

MATERIALS AND METHODS

Fruit of the lanzon in three stages of maturity; namely, green but mature, turning, and ripe, were used in these experiments. They were obtained from the lanzon plantations at Paete, Loñgos, and Los Baños, Laguna. Unless otherwise stated, only normal-sized sound fruit were used. Extreme care was exercised in picking the bunches so as not to bruise or wound them. Within twenty-four hours after picking, the fruit were placed in the apparatus and the experiment began.

The freezing point of the juice of the fruit was measured by a Beckmann thermometer. The juice was extracted by means of a press consisting of two blocks of molave (*Vitex pubescens* Vahl.), one of the Philippine hardwoods (see fig. 1). The larger block had a round hole ten and one-half centimeters in diameter and nine centimeters deep at the center into which the smaller block was made to fit, leaving about two millimeters of surrounding space. Seedless segments of the fruit were frozen stiff (unless otherwise stated) in a tightly stoppered glass container; then thawed and wrapped in clean, dry cheese cloth. The wrapped tissue was placed in the larger block, the smaller one put in place and then pressed by means of a screw. The juice flowed to the outside through a small groove on one side of the larger block. The juice was then placed in test tubes and immersed in cracked melting ice until used. Lanzon pulp pressed this way left a practically dry marc. Ten cubic centimeters of juice were placed in a 25-cc. test tube which was fitted inside a 40-cc. test tube to provide a double-wall. Salt-ice mixture placed in an 18 cm. × 7 cm. glass jar, insulated by a 4 cm. layer of sawdust, was used for freezing.

A certain amount of error is involved in the freezing point determinations by the use of a Beckmann apparatus. Carrick (1924) and Gonzalez (1926 and 1927), using different plant materials, found a significantly higher freezing point when this was determined by means of a Beckmann thermometer, than when thermocouples were used. The difference in the freezing point, especially with juicy tissue, was not great and in the absence of a sensitive apparatus, as the thermocouple, values obtained by the Beckmann thermometer may be taken as relative and approximating the real value. In the case of the lanzon, the difference between the values obtained and the true values is not known at present.

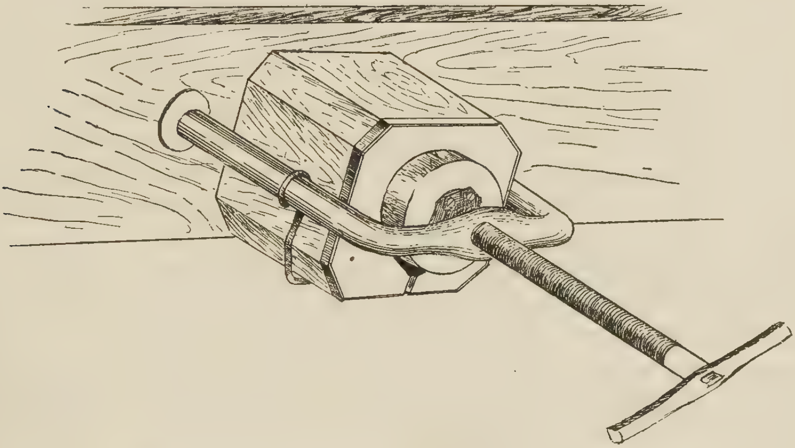

Fig. 1.—Press used in extracting the juice for cryoscopic determinations.

To have a much better control of storage temperature than that found in a commercial storage plant and for convenience in inspecting the fruit at more frequent intervals, improvised storage chambers were devised. Campo (1935) described this apparatus.

Storage temperatures were adjusted three times a day, at 6:30 a. m., at 12:00 noon and at 5:30 p. m., or oftener, adding either crushed ice or hot water as necessary. Six different temperatures were tried in these studies; namely, 0°, 10°, 13°, 16°, 20°, and 27°C. Variation in temperatures in the bath were as follows: the 0°C. was maintained constant by completely filling the bath space with crushed ice and draining off the water once a day; 10° to 13°; 13° to 15.5°; 16° to 18°; 20 to 22°; and 27° to 27.50°C. It must be pointed out in this connection that these maximum variations occurred only in the night time, between 5:30 p. m., and 6:30 a. m., a period of 13 hours. During the day, when adjustment of temperatures was within 5½ hours, the temperature variation was at most 1°C.

There was a maximum temperature variation of 0.5°C. between bath temperature and that of the space in the fruit chamber, and 0.5°C. between any two points within the chamber, at any given time.

At the beginning of the study the bunches of fruit were arranged in racks made of fine cabinet wire with supports of galvanized iron. These racks made inspection of the fruit very convenient as by simply lifting the rack, the fruit could be examined without touching them. Later, however, when working with 13°C., and 16°C. storage temperatures, so large a quantity of fruit was handled that it was impossible to use the racks. The bottom rack, however, was retained to prevent the fruit from coming in contact with the water that condensed on the bottom of the can. In addition to the fruit studied in the fruit chambers, a few bunches in an open box and others in sawdust were placed at room temperature. In general, the use of the apparatus was satisfactory.

Fresh fruits were of average size, Naples yellow with normal flavor and texture and of excellent quality. Inspection for changes in color, texture and flavor was made every other day. "Color Standards and Color Nomenclature" by Ridgway (1912) was used for color determinations. Opinions of various persons regarding flavor and texture were sought.

The rate of respirations of the fruit was measured by the titrametric method described by Gonzalez (1931), using the same apparatus that he employed. Care was exercised in avoiding air leaks. Four temperatures were used in determining the respiratory rate; namely, 0°, 10°, 20°, and 27.5°C. Green, turning, and ripe fruit were used in the experiments. The first temperature was maintained by completely covering the dessicator with crushed ice and draining off the ice water once a day. With the other temperatures, either crushed ice or hot water was added as needed. There was no thermostatic control of temperatures. However, because of good insulation and bi-hourly checking during the day, the temperatures did not vary more than 0.5°C. with the 10°C., and 20°C., and 0.2°C. with the 27.5°C., during the running of the experiments.

Experiments were run in duplicate. At least 14 hours were allowed for the aspirator to draw air through the carbon dioxide and moisture washes before the carbon dioxide output of the fruit was measured. Preliminary trials showed that 3 hours were enough to empty the dessicators of carbon dioxide. Tenth-normal barium hydroxide of known quantity was placed in the suction flask to absorb the carbon dioxide produced by the fruit. Whatever quantity was left unused was titrated against a tenth-normal oxalic acid solution, using phenolphthalein as indicator. The amount of carbon dioxide evolved was calculated in terms of milligrams carbon dioxide per kilogram of fruit per hour duration of the experiment, assuming one cubic centimeter of tenth-normal oxalic acid to be equivalent to 2.2 milligrams of carbon dioxide. An excess of barium hydroxide was always placed in the suction flask.

From one-fourth to one kilogram of fruit was used for respiration studies. The fruit were weighed at the beginning and at the end of the experiment. In the earlier part of the experiment only bunches of fruit were used. But many ants and mealy bugs stayed on the fruit stems and were not easily driven away without injuring the fruit, so the latter were separated from the bunch in later work. It was feared that these insects might introduce errors in the study. In connection with the work on green and turning fruit such a separation was unavoidable because the fruit in a bunch do not all ripen at the same time. So to have fruit of about the same stage of maturity it was necessary to handle them singly. Detaching the fruit, as will be shown later, had no effect on their respiratory activity.

Titration was made as often as every hour with experiments run at higher temperatures because of excessive evolution of carbon dioxide. At lower temperatures the time was much longer. With 0°C., the experiment was, in certain cases, run as long as fifteen hours.

Heinicke's method (1924) for the determination of catalase activity was followed using the apparatus described by Gonzalez (1933). It was found in the preliminary trials that the pulp gave very variable and low catalase activity even when sodium hydroxide solution of various concentrations was used instead of calcium carbonate. This is probably due to the high acidity of the pulp. It was thought, therefore, to use the peel for studying the catalase activity of the fruits. For this purpose a longitudinal strip of the peel weighing 0.5 gram was obtained from a region of the fruit. The sample was placed in a porcelain mortar; then an equal amount of calcium carbonate, a little purified quarts sand and a few drops of rain water just enough to produce a thin pasty covering for the sample were added. The mixture was thoroughly ground until a pasty mass was produced. More water was added to make a total of 10 cubic centimeters of water. The suspension was placed in a 50-cc. clean Erlenmeyer flask, corked, and kept at room temperature for 24 hours before determinations were made.

Four cc. of the well-stirred suspension was made to react with two cc. of fresh hydrogen peroxide (Mallinkrodt 10 volumes). The reaction tube was immersed in a water bath kept at a constant temperature of 30°C. for at least one minute before the preparation and the hydrogen peroxide were caused to mix together by rotating the tube at the rate of 60 complete swings per minute. The time in seconds required to liberate 1 to 3 cc. of oxygen was recorded.

The "Official and Tentative Methods of Analysis" of the Association of Official Agricultural Chemists (1930) was followed in the chemical analysis here reported. From 10 to 15 fruit of normal size and appearance were peeled and the seedless segments passed twice through a meat grinder and mixed together very well. With the apparatus previously described, enough ground tissue was pressed to produce about 40 cc. of juice. Five cubic centimeter aliquots were diluted to about 20 cc. with distilled water and titrated against an 0.08118 N sodium hydroxide solution using phenolphthalein as indicator. Unfortunately, no apparatus was available for the measurement of the hydrogen-ion concentration in connection with the acidity changes in the fruit during storage.

In accordance with the official method, ten-cubic-centimeter picnometers with ground glass and thermometer covers were used in specific gravity determinations. Weighing was done when the temperature of the juice was 20°C.

Five to ten-gram samples from the remainder of the ground tissue were weighed into porcelain dishes, the constant weights of which were known. These were used for moisture determinations. The samples were dried to constant weight in an electric oven at 70°C. At 90°C there was a burning of the tissue.

For the determination of sugar, five to ten grams of the ground tissue were placed in a 400 cc. Pyrex beaker. About 250 cc. of distilled water were added and the sample boiled for one hour. The evaporated water was replaced at frequent intervals. The boiled sample was placed in a 250 cc. volumetric flask, cooled to room temperature, enough lead acetate solution added, and diluted to the mark. The excess lead acetate was precipitated by anhydrous sodium carbonate and filtered. Measured aliquots of the filtrate were used for the determinations of reducing and total sugars, following the gravimetric method of Munson and Walker as given in the official and tentative methods of analysis. Inversion was accomplished at room temperature with dilute hydrochloric acid.

EXPERIMENTS AND RESULTS

1. *Freezing point studies*

The formula suggested by Harris and Gortner (1914) for the correction of supercooling has been applied to the data obtained in these studies. This equation is

$$\triangle = \triangle^1 - (0.0125U\ \triangle^1)$$

where $\triangle$ is the corrected freezing point, $\triangle^1$ the observed maximum freezing point, 0.0125 the heat of liquefaction of ice, and U the amount of supercooling.

a. Freezing point of juice of frozen and unfrozen fruit.—It is generally believed that freezing increases the permeability of plant membranes permitting the release of more solutes than when not frozen, and that the juice expressed from frozen material has a lower freezing point than from the unfrozen. Dixon (1914) and Harvey (1918) found a significant difference between the freezing point of juice of frozen and unfrozen tissues. These findings emphasized the importance of freezing the material before extracting the juice. To check this point with the lanzon, some fruit were peeled and the segments with seeds discarded. The seedless segments were divided into two groups, each group containing the same number of segment from each fruit. Without freezing the tissue, enough segments of one group were pressed to produce 20 cc. of juice. Duplicate freezing point determinations were made on the 20 cc. portions of juice. The other group of seedless segments were frozen stiff before juice extraction and freezing point determinations were made. The average of ten duplicate determinations from each of the groups of frozen and unfrozen tissues are given in table 1. The differences in freezing point between the two treatments being statistically significant, all freezing point determinations here reported were on juice from tissues which had been frozen.

b. Influence of size of fruit on the depression of freezing points.—With Eureka lemon, Gonzalez (1927) found that the freezing point of small fruit (94-95 grams) was 0.18°C. lower (2.171 atmospheres higher in osmotic pressure) than larger fruit. A study of the influence of size on the freezing point of lanzones has been carried out in this work. Fruit were classified into small, average 5.4 grams;

medium, average 10.8 grams; and large, average 17.8 grams. The average of results from 13 duplicate determinations for each of the different sizes are given in table 2.

c. Freezing point of the different parts of the fruit.—Seedless segments of lanzones were cut cross ways into three equal parts designated as stem end, median region and stigmatic end. The pieces were frozen for 5 hours, after which they were thawed at room temperature. Enough tissue to give 20 cc. of juice was pressed. Freezing point determinations were made and averages of 11 duplicate determinations are presented in table 3.

2. Storage studies

a. Influence of maturity at time of harvest on flavor and keeping quality.—Ripe, turning, and green but matured fruit were harvested and placed at room temperature. The ripe fruit remained in good condition for three days. Turning fruit with about 50 per cent colored surface did not ripen normally. Most of them decayed before fully ripening. When they ripened, the texture was soft, the color not very bright and the flavor either very acidic or flat. Green fruit rotted before reaching a 50 per cent turning stage. Because of this abnormal behavior of turning and green fruit even under the best ripening conditions, that is, at room temperature (27° to 30°C.), only ripe fruit were used for studying the effect of different storage temperatures on the flavor and keeping quality of the fruit.

b. Influence of temperature.—Six different storage temperatures were tried in these experiments; namely, 0°, 10°, 13°, 16°, 20°, and 27°C. From preliminary trials it was found that the optimum storage temperature for ripe lanzon lies between 10° and 20°C., because at 10°C. there was a slight browning of the rind, and at 20°C. the fruit remained normal only for a little more than a week. Therefore, more of the fruit were used for the 13° to 15.5°C., and 16° to 18°C. storage trials. Details of the experiment and the result of the storage studies are shown in table 4.

At 10°C. or lower a decidedly adverse effect on the lanzon was observed. At 0°C. patches of Hay's russet appeared on the rind on the third day, making the fruit water-soaked in appearance. On the fifth day the whole rind was cinnamon color. The flavor was impaired, resembling more that of cooked lanzon, although the texture remained quite normal. Fruit stored for this length of time may be used for cooking purposes only.

Those stored at 10°C. to 13°C. developed patches of Natal brown after 5 days in storage, which became darker as the storage period was prolonged. No rotting was observed up to the ninth day and only 3.13 per cent of the fruit had rotted on the twelfth day. Only a few fruit have shattered from the bunches at this time. The appearance, however, was unattractive owing to brown patches on the rind, but the flavor and texture were normal. On the fifteenth day 50.01 per cent of the fruit have rotted. For a market that is not discriminating as to the appearance of fruit the 10° to 13°C. temperature will prove the best in preserving the fruit and maintaining normal flavor and texture. But in our local markets the customers invariably demand a sound fruit, and color of the rind is one of the indices to this, hence the 10°C. temperature would not be advisable.

At 13° to 15.5°C. the fruit remained in excellent condition up to the thirteenth day with only 9.48 per cent of the unmarketable. Of the unmarketable fruit 4.06 per cent was caused by infection of *Rhizopus nigricans* Ehrenberg.[3] The fruit can not be profitably stored much longer than 13 days as the percentage of decay became very high during the period of 13 to 20 days. On the sixteenth day it was 50.21 per cent.

Up to the ninth day the fruit at 16°C. to 18°C. were in excellent condition with only 5.22 per cent decay; 2.32 per cent of this was due to *Rhizopus nigricans* Ehrenberg. On the thirteenth day the decayed fruit amounted to 23.77 per cent. It may be seen from table 4 that the rate of decay of the fruit increased as the temperature was raised. Under the conditions of the experiment 20°C. and 27°C. were very poor storage temperatures for lanzones.

Covering the fruit with sawdust and placing them at room temperature (27°C. to 31°C.) kept the fruit in excellent condition for 7 days with only 25 per cent decay, instead of an average duration of 3 days under common storage in the open at the same temperature.

c. Influence of delay in storage on keeping quality.—During the 1933 lanzon season about 3,000 lanzon fruit were harvested from the College trees. The fruit were picked when there were still light shades of yellowish green color on the stem end of about 20 per cent of the fruit, indicative of not being fully ripe. They were divided into four lots. Two lots were placed in storage a few hours after picking, one of which was kept at 13° to 15.5°C. and the other at 16°C. to 18°C. The remaining two lots were kept at room temperature for two days before they were placed in storage. The results of the experiment are shown in table 5.

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[3] Specimens were examined by Mr. Emiliano F. Roldan of the Department of Plant Pathology of the College of Agriculture.

The importance of immediate storage after picking is shown by the results. When stored immediately after picking only 5.86 per cent of those stored at 16° to 18°C. were unmarketable after 10 days in storage. On the other hand, with the fruit kept at room temperature for 2 days before being placed in storage, 18.75 per cent of those stored at 13° to 15.5°C and 36.60 per cent of those stored at 16° to 18°C. were unmarketable after 9 days. After 12 days in storage there were about twice as many unmarketable fruit in the lots whose storage was delayed for 2 days as in the lots which were stored immediately after picking.

3. Respiration studies

a. Influence of separating the fruit from the bunch.—Separating the fruit from the bunch was necessary for reasons already given. The possibility of wounding was assumed to be avoidable if care was exercised in severing the connection at the abscission layer. If this be feasible, separating the fruit will have a minimum effect on the rate of carbon dioxide output. To verify this point, ripe fruit in bunches were selected for similarity in size, color and appearance; and the rate of carbon dioxide output before and after severing from the bunches, was measured. Studies were made at two temperatures, 27.5°C. and 20°C. In the first experiment (27.5°C.) two bunches were placed in each dessicator. Sample 1 had 36 fruit, weighing 444 grams, and sample 2, 43 fruits weighing 500 grams. After sealing the cover of the dessicators with vaseline and coating with shellac they were placed in the bath, tested for air leak, and all connections made. Air was drawn at once and the first measurement, made six hours later. Five determinations of the respiration of undetached fruit were made after which the dessicators were dismantled. The fruit in sample 1 were left intact, while those in sample 2 were detached by twisting the fruit gently so that the calyx (which is persistent) would go with the fruit. Fruit and stems were returned to the dessicators which were then again covered as before and the air drawn for 14 hours before making measurements of carbon dioxide output of the detached and undetached fruit.

An experiment similar to the one described above was run at 20°C. Sample 1 was composed of 5 bunches consisting of 50 fruit and weighing 589 grams. Sample 2 also was composed of 5 bunches with 60 fruit and weighing 590 grams. The fruit in sample 2 were detached after making 11 measurements. The results of all trials are shown in table 6 and chart 1.

Detaching the fruit from the bunch, when done carefully, did not have a significant effect on the rate of respiration. In the following experiments, mixtures of detached fruit and those in bunches were used.

b. Influence of maturity and temperature on the rate of respiration.—The rate of carbon dioxide output of green, turning, and ripe fruit was measured at 0°, 10°, 20°, and 27.5°C. by the method already described. The results are shown in tables 7 to 18 and charts 2 to 8.

4. Influence of maturity on catalase activity

The catalase activity of the rind of green, turning, and ripe fruit was determined by the method described previously. The results are shown in table 19. With green fruit an average of 14 seconds was required to liberate the first cc. of oxygen; 23.37 seconds for the second cc.; and 36.95 seconds for the third cc.; with turning, 12.5 seconds for the first cc.; 17.10 seconds for the second cc.; and 25.5 seconds for the third cc.; and with ripe, 18.7 seconds for the first cc.; 30.3 seconds for the second cc.; and 44.3 seconds for the third cc. Duplicate determinations did not check very closely, probably because of the unequal amount of tissue in the determinations. This is due to the difficulty of grinding the rind into a very fine mass.

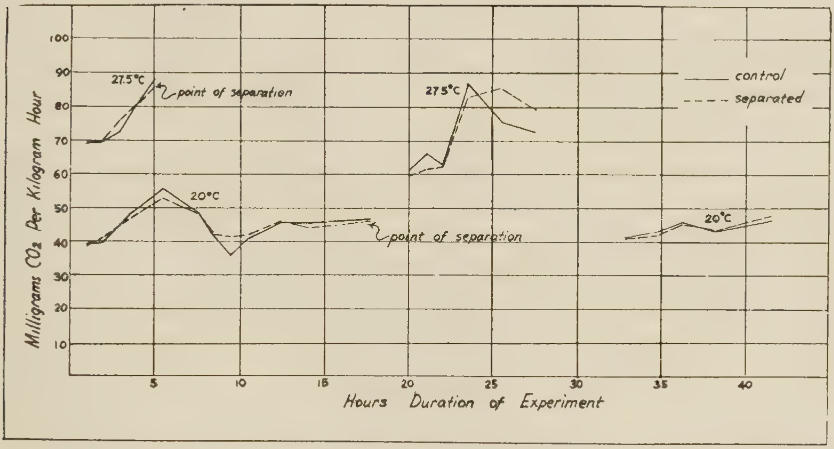

Chart 1.—Influence of separating the fruits from the bunch on the respiration of ripe lanzones at 20° and 27.5°C. The gaps between the curves with identical temperatures represents the period when the respiration apparatus was dismantled and reset, when the fruits of one sample of each set were separated from the bunches, and the period of 14 hours when air was drawn from the respiration apparatus before readings were resumed.

5. The more important chemical changes in the fruit while in storage

Results of analyses on the changes in moisture, specific gravity, titratable acidity and reducing and total sugars in the fruit during storage are presented in table 20.

DISCUSSION OF RESULTS

The juice extracted from the tissue which was first frozen gave a lower freezing point than that of the unfrozen tissue (tables 1 and 2). The maximum value obtained from unfrozen tissue was -1.230°C. (14.80 atmospheres); the minimum, -1.509°C. (18.15 atmospheres); and the average, -1.378°C. ± 0.012 (16.58 ± 0.145 atmospheres). From previously frozen tissue the maximum was -1.241°C. (14.93 atmospheres); the minimum, -1.648°C. (19.82 atmospheres); and the average, -1.454°C. ± 0.017 (17.49 ± 0.205 atmospheres. The average difference was statistically significant, being 0.076°C. ± 0.018. Other workers have found that with succulent tissues (tissues of lanzones are succulent) there is not so much need for freezing the cells before extracting the juice as with woody tissues. Gonzalez (1927) found no consistent difference between the freezing points of expressed juice from frozen and unfrozen tissue in a brand of Valencia orange. In a second brand he found a slightly lower freezing point in the unfrozen fruit. Carrick (1930) found no significant difference in the freezing point of extracted sap from frozen and unfrozen grapes. With less succulent tissues, however, as in the case of *Hedera helix* and *Ilex aquifolium* (Dixon, 1914) and cabbage leaves (Harvey, 1918), freezing the material before extracting the juice is necessary. With the work of Harvey, the lower the temperature used for freezing, the lower was the depression obtained.

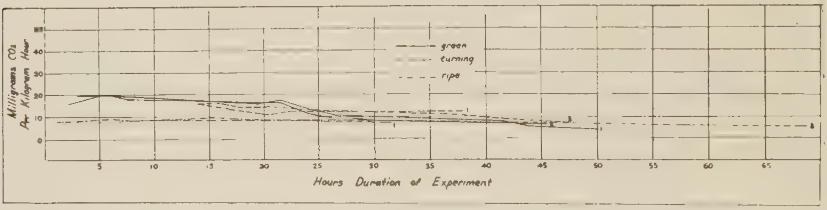

Chart 2.—Respiration of green, turning and ripe lanzones at 0°C.

Tables 1, 2 and 3 show that the minimum freezing point of juice of ripe lanzon extracted from frozen tissue was -2.023°C. (24.32 atmospheres) and the maximum, -1.241°C. (14.93 atmospheres). The average of all the determinations (164 in all) was –1.673°C. (20.12 atmospheres).

Data presented in table 2 show that the larger the lanzon fruit, the lower the freezing point. A maximum freezing point of –1.366°C. (16.43 atmospheres) and a minimum of -1.708°C. (10.54 atmospheres) were observed for small fruit (average weight, 5.4 grams). The average freezing point of 13 duplicate determinations was –1.571°C. ± 0.013 (18.89 atmospheres ± 0.157); with medium-sized fruit (average weight, 10.8 grams); the maximum was -1.562°C. (18.78 atmospheres) and the minimum, -1.865°C. (22.42 atmospheres) making for all determinations an average of –1.726°C. ± 0.013 (20.75 atmospheres ± 0.157). Large fruit (average weight, 17.8 grams) had a maximum freezing point of –1.578°C. (18.98 atmospheres), a minimum of -2.066°C. (24.82 atmospheres) and an average of -1.791°C. ± 0.02 (21.53 ± 0.241 atmospheres). In atmospheres, the osmotic pressure of the large fruit is higher by 0.78 than that of the medium-sized fruit and by 2.64 higher than that of the small fruit. These differences are statistically significant. Apparently, with lanzones, the relationship of size and freezing point is the opposite of that of the lemon. Gonzalez (1927) reported that with Eureka lemon, the small fruit (94-96 grams) had a freezing point of 0.18°C. (2.171 atmospheres) lower than that of the larger fruit (123-127 grams). With the lanzon the differences can not be

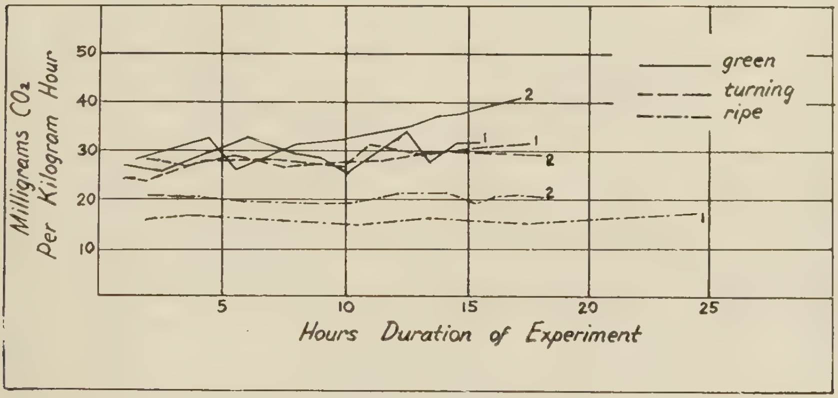

Chart 3.—Respiration of green, turning and ripe lanzones at 10°C.

attributed to the stage of maturity of the fruit as special attention was given to select comparable materials. As the greater part of the solute in the lanzon (table 20) appears to be the sugars, this finding tends to corroborate the common belief that large-sized fruit are sweeter than the small-sized. This may be attributed to the conditions attendant on the better development of the larger fruit. The question of variety or difference in strain does not enter here as all the grades of specimens compared (the large, the medium, and the small) were selected from the same tree.

No significant difference was detected between the freezing point of the stem end, median region and stigmatic end of lanzones.

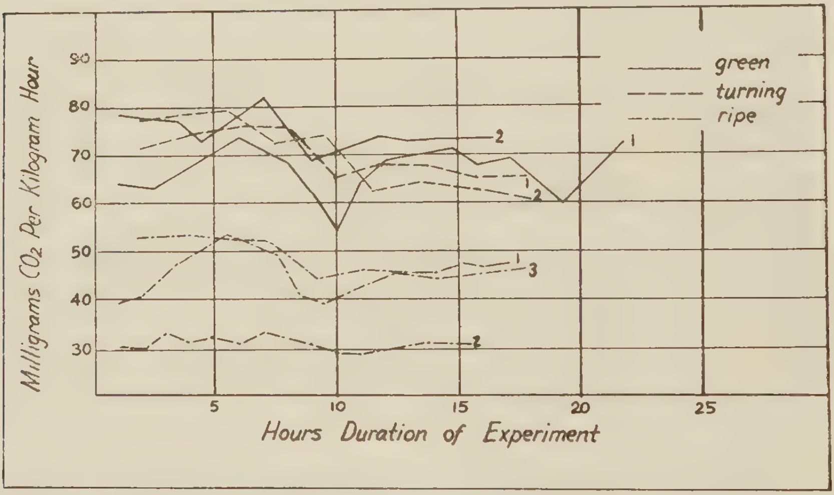

Chart 4.—Respiration of green, turning and ripe lanzones at 20°C.

Table 3 shows that the stem end froze at an average of –1.705°C. ± 0.023 (20.50 ± 0.277 atmospheres), the median region at –1.730°C. ± 0.014 (20.30 ± 0.169 atmospheres), and the stigmatic end at -1.686°C. ± 0.019 (20.27 ± 0.0229 atmospheres). There was no regularity in the value obtained from individual determinations. With larger fruit as the apple (Carrick, 1924) and with certain citrus fruits, the pineapple, and the mango (Gonzalez, 1927), there seems to be a localization of solute, as indicated by the depression of the freezing point.

Table 4 shows that of the different storage temperatures tried, 13°C. to 15.5°C. proved the best. At 10°C. to 13°C. and at temperatures lower than this, the fruit became water-soaked, while at 16°C.

to 18°C. and above, the fruit decayed rapidly. At 13°C. to 15.5°C. lanzones remained in excellent condition for 13 days with only 9.48 per cent decay. Of this amount, 4.06 per cent may be saved by practicing more care in picking the fruit so as to avoid bruising, as the infecting organism, *Rhizopus nigricans,* attacked only the fruit with unsound epidermis.

Table 5 shows the importance of placing the harvested fruit in storage as soon as possible. There were fully 2 to 3 times as many unmarketable fruit in lots whose storage was delayed than in the lots which were immediately placed in storage after harvesting.

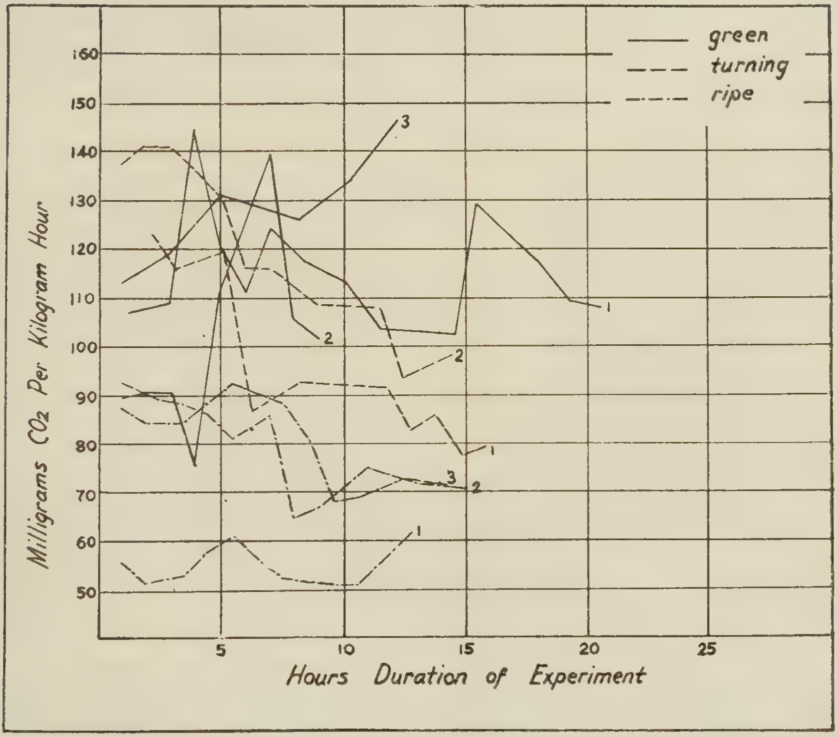

Chart 5.—Respiration of green, turning and ripe lanzones at 27.5°C.

Data presented in tables 6 to 18 and charts 2 to 9 seem to indicate that the rate of carbon dioxide output of lanzones decreases as the fruit advances in maturity. For example, at 0°C. the average initial rate of respiration of green fruit was 17.37 mgm., of turning, 15.37 mgm., and of ripe, 7.91 mgm., per kilogram hour. As will be pointed out later, there was a drop in the respiratory rate of fruit of different stages of maturity at this temperature, so that comparison must be between readings for equal duration of exposure only. From chart 2 can be estimated the rates of respiration of the different samples after 31.5 hours of exposure. These are approximately 9 mgm. for the green; 12 mgm., for the turning; and 7.8 mgm. for the ripe. Taking the averages of all determinations up to the 31.5 hour of exposure, the following values were obtained: 13.77 mgm. for green, 13.46 mgm. for turning, and 8.45 mgm. for ripe. The respiration of green to turning to ripe, using the general averages, is 1:0.98:0.61. Since at other temperatures no depressive effect on the rate of carbon dioxide output of fruit in all stages of maturity was noted, the general averages of all determinations may be used in computing the respiratory ratios of green to turning to ripe.

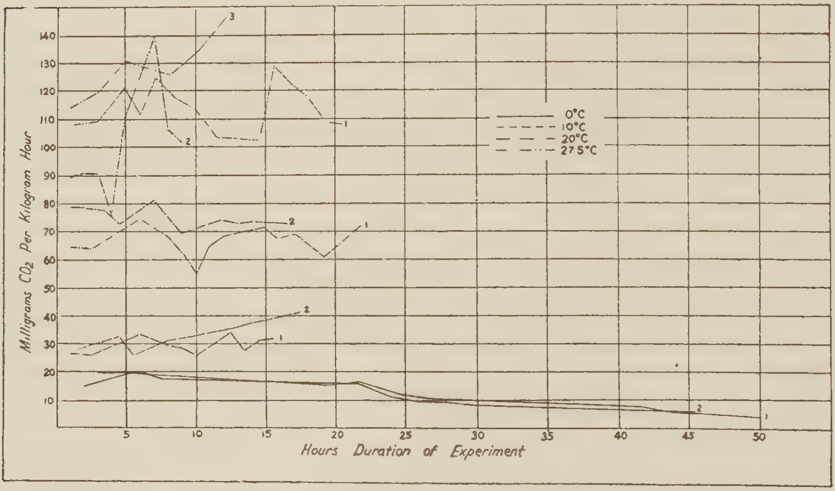

Chart 6.—Respiration of green lanzones at 0°, 10°, 20° and 27.5°C.

These were, at 10°C., 1:0.89:0.577; at 20°C., 1:0.99:0.586; and at 27.5°C., 1:0.94:0.61. These data seem to be the opposite of the findings of other workers on other fruit. Gerber (1896), Gore (1914), Magness (1920), Harding (1929), Enrile (1930), Pascual (1930), and Gonzalez (1931) found that the rate of respiration of the fruit they studied increased as the specimens advanced in maturity, reaching their maximum at the ripe stage. With tomato, Gustafson (1930) found that the minimum rate of respiration was reached when they were about to change in color. After this, there was an increase until they became orange red.

At 0°C. there was a decline in carbon dioxide output of all the fruit, irrespective of maturity. The effect was more severe in the green specimen. Thus, the decreases in value from the initial rates after 31.5 hours of exposure were 8.37 mgm. for green, 3.37 mgm. for turning, and 0.11 mgm. for ripe. No drop in the rate of carbon dioxide output was observed at 10°C., 20°C., and 27.5°C. If any, there was a slight tendency for the rate to increase for the first few hours, to decrease, then to remain about level. At 10°C. there was a gradual rise in the rate for green and turning, the ripe staying more or less constant. At 27.5°C. the values were rather inconsistent. These findings may be interpreted to mean that at 0°C. certain physiological activities of the fruit were offset, a harm not produced at temperatures from 10°C. and higher. This harm was further manifested in the browning of the rind of the fruit at different stages of maturity after an exposure of 3 days to 0°C. At 10°C. there was also noted a slight browning of the rind of ripe fruit but this appeared only after 5 days in storage.

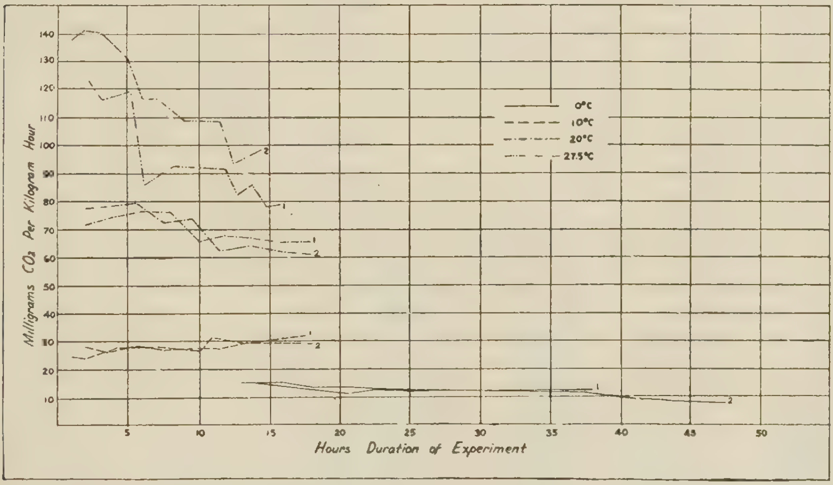

Chart 7.—Respiration of turning lanzones at 0°, 10°, 20° and 27.5°C.

Data presented in tables 7 to 18 and charts 2 to 9 show that the higher the temperature the greater was the rate of respiration of the fruit. Green fruit respired at an average rate of 31.6 mgm., at 10°C.; 70.86 mgm. at 20°C.; and 114.87 mgm. at 27.5°; turning fruit, 28.18 mgm. at 10°C.; 70.21 mgm. at 20°C.; and 108.01 mgm. at 27.5°C.; and ripe fruit, 18.24 mgm. at 10°C., 41.54 mgm. at 20°C., and 69.7 mgm. at 27.5°C. The ratio of the respiratory rate of green lanzones at 0°C., to 10°C., to 20.°C., to 27.5°C., was 1:2.63:5.89:9.34; that of turning, 1:2.25:5.61:8.63 and that of ripe, 1:2.27:5.18:8.69.

These increases in the rate of carbon dioxide output as the temperature was raised were in accordance with the van't Hoff-Arrhenius law. Other fruit also show a similar increase. Thus, Gore (1911) reported that the rate of respiration of 49 different kinds of fruit he studied increased from 1.89 to 3.01 times, or an average of 2.376 times, for each 10°C., rise in temperature. Gonzalez (1927) found that the ratio of normal respiration of citrus fruits at 20°C. is much higher than at 0°C., the ratio being 8:1 with Washington Navel orange, 4:1 with Valencia orange, and 5:1 with Eureka lemon. Carrick (1928), studying the effect of freezing on the respiration of apples, found that the rate of carbon dioxide output at 20°C., was more than 7 times as much as at 0°C. Overholser (1928) measured the respiration of Fuerte avocado at average temperatures of 21.1°C., 7.4°C., and 0°C., and obtained a ratio of about 15:4:1. Gonzalez (1931) found that the respiration of matured chico fruit is at least 19 times more active at 28.5°C. than at 0°C., an increase that is far beyond the theoretical expectation.

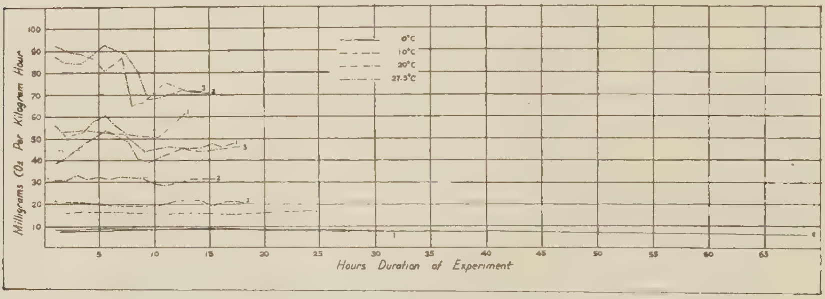

Chart 8.—Respiration of ripe lanzones at 0°, 10°, 20° and 27.5°C.

The catalase activity of the rind of green and turning fruit was almost equal, the latter being a little more active, while that of ripe fruit was only about one-third to one-half as active as that of the turning. If catalase activity is taken as a measure of certain metabolic processes in plant tissue (Carrick, 1929), the above finding may be another support to the data on respiration, where it was found that green and turning fruit gave off more carbon dioxide than ripe fruit, other things being equal. But there was no such agreement between the data on respiration and catalase activity of green and turning fruit. It seems that the relationship of catalase and respiration in plant tissues is not a settled question. Appleman

(1916), Enrile (1930), and Pascual (1930) found a direct correlation between catalase activity and respiration. Crocker and Harrington (1918) found such a correlation in Johnson grass seed but not in Amaranthus seed. Heinicke (1924) found no consistent correlation between the rate of carbon dioxide output of dormant apple twigs and their catalase activity. Drain (1916) stated that the rate of respiration and catalase activity in the apple are not closely correlated.

In fruit stored at 13°C. there was little change in dry matter and total sugars; an increase in specific gravity and reducing sugars; and decrease in titratable acidity. A loss of only 0.66 per cent in dry matter, an increase of 0.006 in specific gravity, a decrease of 0.059 normal in titratable acidity, and an increase of 0.973 per cent reducing sugars, and only 0.206 per cent decrease in total sugars were recorded with fruit kept at 13°C., for 10 days. These results again point to the desirability of using this temperature for storing lanzones.

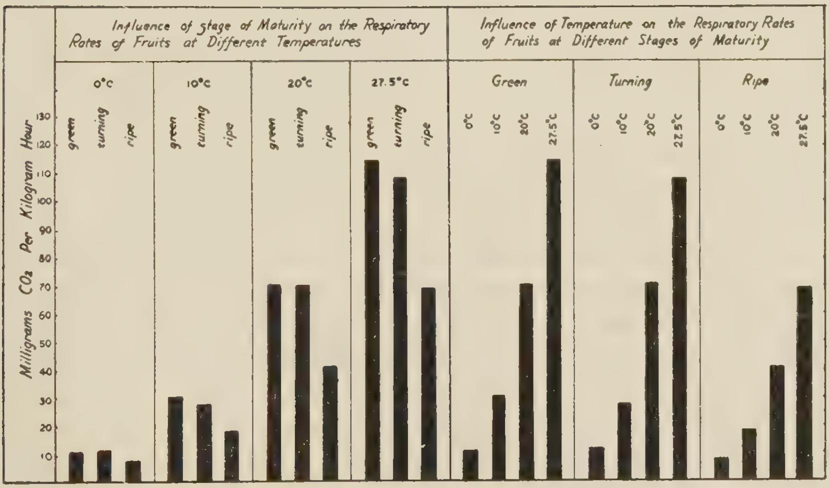

Chart 9.—Summary graph showing the influence of temperature and stage of maturity on the respiratory rate of lanzones.

At higher temperatures there were more losses in dry weight and the sugars because of increased respiration, while at temperatures lower than 13°C., the acidity tended to be high and the sugars to be low. Fruit kept at 10°C. for 14 days had the highest titratable acidity although the fruit did not show noticeable change in flavor.

SUMMARY OF CONCLUSIONS

1. An apparatus for extracting the juice of plant materials and for determining the freezing point of the juice is described.

2. There was a significant difference in the freezing point of the juice extracted from unfrozen and previously frozen tissues. The average of 10 duplicate determinations from each treatment was -1.378°C. ± 0.012 (16.58 ± 0.145 atmospheres) for the unfrozen, and -1.454°C. ± 0.017 (17.49 ± 0.205 atmospheres) for the frozen, giving a difference of 0.076°C. ± 0.018 (0.91 ± 0.217 atmospheres).

3. The average freezing point of 164 determinations on juice from frozen lanzones was -1.672°C. (20.12 atmospheres). A minimum of -2.023°C. (24.32 atmospheres) and a maximum of -1.241°C. (14.93 atmospheres) were recorded.

4. There was a correlation between the size of the fruit and the depression of the juice; the larger the fruit the lower the freezing point. Average freezing points were -1.571°C. ± 0.013°C. (18.98 ± 0.157 atmospheres) for small, -1.726°C. ± 0.013°C. (20.75 ± 157 atmospheres) for medium, and -1.791°C. ± 0.02 (21.53 ± 0.241 atmospheres) for large fruit.

5. There were no significant differences in the freezing points of the juice from the stem end, median region and stigmatic end of the fruit. Averages for the different regions were -1.705°C. ± 0.023 (20.50 ± 0.277 atmospheres), for the stem end, -1.730°C ± 0.014 (20.80 ± 0.169 atmospheres) for the median region, and -1.686°C. ± 0.019 (20.27 ± 0.220 atmospheres) for the stigmatic end.

6. Green and turning fruit failed to ripen even at room temperatures (27°C. to 31°C.).

7. Covering the fruits with sawdust prolonged the life of the fruit to 7 days instead of 3 days when kept at room temperature.

8. Of the different storage temperatures used, 13°C to 15.5°C. proved to be the best. Ripe lanzones remained in excellent condition for 13 days with only 9.48 per cent of the fruit unmarketable, and 4.06 per cent of this amount was due to *Rhizopus nigricans*. This loss may be prevented by using more care in picking, as this organism attacks only the fruit with unsound epidermis.

9. Immediate storage after picking minimized fruit spoilage by 1 3 to 2 3 when compared with fruit that were kept at room temperature for 2 days after picking, before being placed in storage.

10. At storage temperatures of 10°C. to 13°C. and lower, lanzon fruit developed browning of the rind and a water-soaked appear-

ance. At 16°C. to 18°C. and higher the rate of decay was much faster than at 13°C. to 15.5°C.

11. The rate of carbon dioxide output of the lanzon decreased as the fruit advanced in maturity. The initial rate of respiration of green fruit at 0°C. was 17.37 milligrams, of turning, 15.37 milligrams; and of ripe, 7.91 milligrams per kilogram hour. The averages for all determinations up to 31.5 hours exposure were 13.77 milligrams for green, 13.46 milligrams for turning, and 8.00 milligrams for ripe.

12. At 0°C. there was a decline in the carbon dioxide output of fruit of all stages of maturity. The green fruit were more affected than either the turning or the ripe. No decline in respiration was observed at 10°C., 20°C., and 27.5°C.

13. The higher the temperature, the higher was the respiratory rate of lanzones. The ratio of the respiratory rate of green lanzones at 0°C., to 10°C., to 20°C., to 27.5°C. was 1:2.63:5.89:9.54; that of turning, 1:2.25:5.61:8.63; and that of ripe, 1:2.27:5.18:8.69.

14. The catalase activity of the rind of turning fruit was a little above that of green fruit while that of ripe fruit was only from about one-third to one-half as active as that of turning.

15. In fruit stored at 13°C. to 15.5°C. there was very little change in dry matter and total sugars, an increase in specific gravity and reducing sugars, and a decrease in titratable acidity. These changes are all in favor of using this temperature for storing lanzones.

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TABLE 1

Average depression of juice of frozen and unfrozen fruits of lanzones from 10 duplicate determinations

TREATMENT	MAXIMUM		MINIMUM		AVERAGE	
		Osmotic pressure		Osmotic pressure		Osmotic pressure
	°*C*	*atmospheres*	°*C*	*atmospheres*	°*C*	*atmospheres*
Unfrozen .	1.230	14.80	1.509	18.15	1.378 + 0.012	16.58 + 0.145
Frozen . . .	1.241	14.93	1.648	19.82	1.454 + 0.017	17.49 + 0.205

TABLE 2

Average depression of small, medium and large fruits from 13 duplicate determinations

TREATMENT	MAXIMUM		MINIMUM		AVERAGE	
		Osmotic pressure		Osmotic pressure		Osmotic pressure
	°*C*	*atmospheres*	°*C*	*atmospheres*	°*C*	*atmospheres*
Small (5.4 g.)	1.366	16.43	1.708	20.54	1.571 + 0.013	18.89 + 0.157
Medium (10.8 g.)	1.562	18.78	1.865	22.42	1.726 + 0.013	20.75 + 0.157
Large (17.8 g.)	1.578	18.98	2.066	24.82	1.791 + 0.020	21.53 + 0.241

TABLE 3

Average depression of juice from different regions of the lanzones from 11 duplicate determinations

REGION MEASURED	MAXIMUM		MINIMUM		AVERAGE	
		Osmotic pressure		Osmotic pressure		Osmotic pressure
	°*C*	*atmospheres*	°*C*	*atmospheres*	°*C*	*atmospheres*
Stem end .	1.423	17.12	2.023	24.32	1.705 + 0.023	20.50 + 0.277
Median . .	1.456	17.51	1.881	22.61	1.730 + 0.014	20.80 + 0.169
Stigmatic end	1.393	16.76	1.897	22.80	1.686 + 0.019	20.27 + 0.229

TABLE 4

Influence of temperature on flavor and keeping quality

STORAGE TEMPERATURE	NUMBER OF DAYS IN STORAGE	TOTAL NUMBER OF FRUIT USED	CONDITION OF FRUIT WHEN INSPECTED								GENERAL REMARKS
			One-third of fruit decayed	One-half of fruit decayed	Two-thirds of fruit decayed	Whole fruit decayed	Color	Flavor	Texture	Quality	
			per cent	*per cent*	*per cent*	*per cent*					
°C.	3	45	00.00	00.00	00.00	00.00	Patches of Hay russet	normal	normal	fair	Water-soaked appearance. Not attractive.
0°C.	5	40	00.00	00.00	00.00	00.00	Solid cinnamon	fermented	softer than normal	poor	No falling off, but stems were wilted. May be good for sweet making.
10°C. to 13°C.	5	64	00.00	00.00	00.00	00.00	Small patches Natal Brown	normal	normal	good	Fruits in good condition, but spots made them unattractive.
	9		00.00	00.00	00.00	00.00	Spots of Sepia chocolate	normal	normal	fair	Not good for selling fresh because of poor appearance.
	12	—	3.13	00.00	00.00	00.00	Brown patches	normal	normal	poor	Fruits begin falling off.
	15	—	18.75	21.88	6.25	00.00	Burnt amber patches	normal	soft	very poor	Rind tight on pulp and wilted. Flesh under brown spots rotting.
13°C. to 15.5°C.	5	221	1.81	00.90	00.90	00.45	Naples yellow	normal	normal	excellent	Some fruits firm and as good as fresh. Some rotting caused mostly by *Rhizopus nigricans* Ehrenberg. A few fruits have fallen off.
	9	—	1.81	00.00	00.00	00.00	Naples yellow	normal	normal	excellent	No appreciable difference from fruits stored 5 days.
	13	—	00.90	2.26	00.45	00.00	Naples yellow	normal	normal	excellent	Apparently as good as those stored for 9 days.
	16	—	4.98	8.60	4.98	22.17	Naples yellow with tiny brown spots	normal	normal	very good	Five hours after taking from storage, color changed to Warm Buff. Stems badly wilted.

TABLE 4 (Continued)

STORAGE TEMPERATURE	NUMBER OF DAYS IN STORAGE	TOTAL NUMBER OF FRUIT USED	CONDITION OF FRUIT WHEN INSPECTED								GENERAL REMARKS
			One-third of fruit decayed	One-half of fruit decayed	Two-thirds of fruit decayed	Whole fruit decayed	Color	Flavor	Texture	Quality	
°C.			per cent	per cent	per cent	per cent					
16°C. to 18°C.	5	172	1.16	00.00	00.00	1.16	Naples yellow	normal	normal	excellent	Fruits began falling off. Decayed fruits due to *Rhizopus nigricans* Ehrenberg.
	9	—	1.74	00.00	1.16	00.00	Naples yellow	normal	normal	excellent	Fruits almost as good as fresh.
	13	—	6.40	4.07	1.16	6.92	Naples yellow	normal	normal	excellent	No apparent difference from those stored for all fallen off from bunches.
	16	—	12.79	11.05	12.21	10.47	Naples yellow	normal	normal	good	Color changed to Warm Buff 5 hours after taking from storage.
20°C. to 22°C.	5	119	00.00	00.84	00.00	00.00	Naples yellow	normal	normal	excellent	Fell-off easily when touched. Quality as good as fresh.
	8	—	3.36	2.52	00.84	00.00	Naples yellow	almost normal	normal	very good	Flavor not as sweet as those stored for 5 days.
	10	—	3.36	2.52	00.84	00.84	Naples yellow	fermented	soft	fair	Rind tight on pulp because of wilting.
	12	—	9.24	4.20	1.68	3.36	Naples yellow	fermented	soft	poor	Flavor as if fermented and tending to be flat.
27°C. to 27.5°C.	5	61	11.48	1.64	1.64	1.64	Naples yellow	normal	normal	very good	Stems dry and fruits fell-off easily when touched.
	7	—	11.48	14.75	1.64	11.48	Naples yellow	tends to be flat	normal	good	All fallen-off. Flavor not very good.

TABLE 5

Influence of delay in storage on keeping quality

STORAGE TEMPERATURE	NO. OF DAYS IN STORAGE	TOTAL NUMBER OF FRUIT USED	CONDITION OF FRUIT WHEN INSPECTED					REMARKS
			1/3 decayed	1/2 decayed	2/3 decayed	Whole fruit decayed	Total number	
			per cent	*per cent*	*per cent*	*per cent*	*per cent*	
13°C. to 15.5°C.	10	512	2.73	2.54	0	.59	5.86	Placed in storage after picking. 20% of fruits not fully ripe.
	12		22.46	15.04	6.84	4.49	48.83	
16°C. to 18°C.	10	808	3.96	2.97	1.24	1.98	10.15	
	12		16.46	9.16	8.42	10.27	44.31	
13°C. to 15.5°C.	9	661	8.77	7.41	0.91	1.66	18.75	Placed in storage two days after picking. 20% of fruits not fully ripe.
	12		13.62	14.98	16.34	34.95	79.89	
16°C. to 18°C.	9	1163	6.45	10.57	9.61	9.97	36.60	

TABLE 6

Influence on the respiration of ripe lanzones of separating the fruits from the bunch

SET NO. AND TEMPERATURE	TITRATION NUMBER	DATE	DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KGM. HR.	
				Sample 1	Sample 2
		1931	*hours*		
I (27.5°C.)	1	Sept. 1	1.00	69.04	69.26
	2		1.00	69.51	69.68
	3		1.00	72.32	75.94
	4		1.00	80.31	80.11
	5		1.00	87.82	85.11
				Not separated	Separated
	6	Sept. 2	1.00	61.05	59.25
	7		1.00	65.28	61.75
	8		1.00	62.93	62.59
	9		1.50	85.85	82.94
	10		2.00	75.61	85.53
	11		2.00	72.32	79.28
II (20°C.)	1	Oct. 4	1.00	39.25	38.66
	2		1.00	39.60	41.49
	3		1.50	47.66	46.34
	4		2.00	55.19	53.02
	5		2.00	49.76	48.76
	6		1.00	41.00	42.20
	7	Oct. 5	1.00	36.44	42.08
	8		1.00	40.30	42.20
	9		2.00	45.38	45.57
	10		1.75	45.05	44.59
	11		3.50	47.26	46.71
				Not separated	Separated
	12	Oct. 6	1.00	41.35	40.79
	13		2.00	43.63	42.74
	14		1.50	45.56	45.15
	15		2.00	43.60	43.80
	16		3.25	46.58	47.69

TABLE 7

Respiration of green lanzones at 0°C.

SET NO.	TITRATION NO.	DATE	HOURS' DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	Sept. 6	2.00	13.04	17.12	15.08
	2		3.25	19.92	18.68	19.30
	3	7	14.25	13.40	18.56	15.98
	4		2.00	11.93	13.46	17.70
	5		3.00	11.93	12.58	12.26
	6		2.00	9.60	10.53	10.07
	7	8	15.00	7.43	9.13	8.28
	8		2.50	4.89	6.55	5.72
	9		2.00	4.51	5.85	5.18
	10		4.00	4.07	5.56	4.82
Average				10.07	11.80	10.94
II	1	Sept. 9	3.00	19.06	20.25	19.66
	2		3.00	19.50	19.78	19.64
	3		1.50	17.76	17.76	17.76
	4	10	14.00	15.62	16.44	16.03
	5		2.50	11.31	10.94	11.13
	6		2.00	9.67	9.86	9.77
	7		2.00	9.34	9.50	9.42
	8		2.00	8.12	8.88	8.50
	9	11	15.50	6.14	6.53	6.34
Average				12.95	13.33	13.14
General average of all determinations				—	—	12.04

TABLE 8

Respiration of green lanzones at 10°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	Sept. 17	1.00	26.37	27.20	26.79
	2		1.50	24.97	26.04	25.51
	3		3.50	34.38	33.06	33.72
	4		2.00	29.01	30.41	29.71
	5	18	1.00	27.33	29.67	28.50
	6		1.00	23.49	27.20	25.35
	7		2.50	32.80	35.40	34.10
	8		1.00	27.33	28.18	27.76
	9		1.00	28.82	34.12	31.47
	10	19	1.00	32.61	31.15	31.88
Average				28.71	30.24	29.48
II	1	Sept. 23	1.50	29.74	26.77	28.26
	2		3.00	33.30	32.65	32.98
	3		1.00	26.45	25.47	25.96
	4		2.50	30.95	31.74	31.35
	5	24	2.00	32.81	32.57	32.69
	6		2.75	35.08	36.15	35.62
	7		1.25	36.05	38.79	37.42
	8		1.00	39.18	37.22	38.20
	9		2.50	40.47	41.43	40.95
Average				33.78	33.64	33.71
General average of all determinations				—	—	31.60

TABLE 9

Respiration of green lanzones at 20°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
I	1	*1931* Sept. 17	1.00	65.85	63.58	64.72
	2		1.50	62.71	65.24	63.98
	3		3.50	76.69	73.02	74.86
	4		2.00	65.85	70.44	68.15
	5	18	1.00	59.89	64.52	62.21
	6		1.00	54.25	55.79	55.02
	7		1.00	66.79	62.65	64.72
	8		1.00	65.54	71.99	68.77
	9		2.75	72.06	70.72	71.39
	10	19	1.00	70.55	65.76	68.16
	11		1.50	67.73	70.64	69.19
	12		2.00	57.07	63.77	60.42
	13		2.50	76.01	68.82	72.42
Average				66.23	66.69	66.46
II	1	Sept. 23	1.00	78.36	78.36	78.36
	2		1.00	77.99	78.06	78.03
	3		1.50	79.87	75.85	77.86
	4		1.00	74.97	72.71	73.84
	5		2.50	87.71	75.95	81.83
	6	24	2.00	71.58	66.69	69.14
	7		2.75	74.53	73.70	74.12
	8		1.25	75.71	70.22	72.97
	9		1.00	78.36	68.57	73.47
	10		2.50	75.35	70.83	73.09
Average				77.44	73.09	75.27
General average of all determinations				—	—	70.86

TABLE 10

Respiration of green lanzones at 27.5°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	July 21	1.25	108.64	106.16	107.40
	2		1.75	108.97	109.97	109.47
	3		1.00	137.16	152.48	144.82
	4		1.00	153.84	87.69	120.77
	5		1.00	105.34	117.76	111.55
	6		1.00	117.76	131.73	124.75
	7		1.50	115.50	119.25	117.38
	8		1.50	110.58	117.05	113.82
	9	22	1.50	97.00	110.45	103.73
	10		1.50	97.78	108.77	103.28
	11		1.50	98.68	105.80	102.24
	12		1.00	126.68	132.70	129.69
	13		1.50	123.00	120.54	121.77
	14		1.00	126.68	107.48	117.08
	15		1.25	103.98	115.31	109.65
	16		1.25	99.33	115.93	107.63
Average				114.43	116.19	115.31
II	1	Aug. 3	1.00	81.29	98.51	89.90
	2		1.00	72.62	109.17	90.90
	3		1.00	73.55	107.04	90.30
	4		1.00	65.26	86.80	76.00
	5		1.00	108.39	112.30	110.35
	6		2.00	139.92	139.95	139.94
	7		1.00	103.97	107.04	105.51
	8		1.00	97.33	106.51	101.92
Average				92.79	109.04	100.92
III	1	Sept. 6	1.00	104.47	122.54	113.51
	2		2.00	113.41	126.05	119.73
	3		2.00	127.75	133.93	130.84
	4		3.25	128.25	122.32	125.29
	5	7	2.00	126.67	142.68	134.68
	6		2.00	141.28	151.25	146.27
Average				123.64	133.13	128.39
General average of all determinations				—	—	114.87

TABLE 11

Respiration of turning lanzones at 0°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	Sept. 12	14.00	15.87	15.09	15.48
	2		3.00	13.75	13.04	13.40
	3		3.50	9.72	12.19	10.96
	4		2.00	12.89	12.20	12.55
	5		2.00	12.12	12.19	12.16
	6	13	13.50	12.30	11.96	12.13
Average				12.78	12.78	12.78
II	1	Sept. 15	13.00	15.44	15.06	15.25
	2		3.00	14.96	16.78	15.87
	3		2.00	14.34	13.98	14.16
	4		2.50	14.21	15.41	14.81
	5		3.00	12.67	13.05	12.86
	6	16	14.00	11.58	11.67	11.63
	7		3.00	9.14	9.74	9.44
	8		3.00	8.31	8.49	8.40
	9		4.00	7.64	7.77	7.71
Average				12.03	12.44	12.24
General average of all determinations				—	—	12.51

TABLE 12

Respiration of turning lanzones at 10°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	Sept. 25	1.00	23.21	25.65	24.43
	2		1.00	23.21	24.08	23.65
	3		2.25	26.49	28.38	27.44
	4		2.75	26.47	28.55	27.51
	5		3.00	26.20	27.57	26.89
	6	26	1.00	30.49	31.82	31.16
	7		2.25	28.36	30.94	29.65
	8		2.75	29.54	31.79	30.67
	9		1.50	29.89	33.50	31.70
Average				27.10	29.14	28.12
II	1	Sept. 2	2.00	28.44	27.13	27.79
	2		1.50	25.45	26.62	26.04
	3		2.00	29.22	27.50	28.36
	4		2.00	26.88	26.37	26.63
	5		2.00	26.88	27.13	27.01
	6	3	2.00	30.39	29.00	27.70
	7		2.00	30.00	29.00	29.50
	8		2.50	29.92	29.54	29.73
	9		2.00	29.22	29.76	29.49
Average				28.49	28.01	28.25
General average of all determinations				—	—	28.18

TABLE 13

Respiration of turning lanzones at 20°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	Sept. 29	2.00	69.39	73.29	71.34
	2		2.00	73.73	76.06	74.90
	3		2.00	75.59	77.29	76.44
	4		2.00	74.35	78.22	76.29
	5	30	2.00	64.75	66.51	65.63
	6		1.75	67.62	69.33	68.48
	7		2.00	66.60	65.75	67.18
	8		2.00	64.47	66.51	65.49
	9		2.00	64.44	66.82	65.63
Average				68.99	71.31	70.15
II	1	Oct. 2	2.00	74.69	80.81	77.75
	2		1.50	75.10	82.44	78.77
	3		2.00	75.91	83.26	79.59
	4		2.00	67.79	77.75	72.77
	5		2.00	70.40	77.75	74.08
	6	3	2.00	60.61	63.67	62.14
	7		2.00	60.61	68.44	64.53
	8		2.50	59.75	64.65	62.20
	9		2.00	58.89	62.44	60.67
Average				67.08	73.47	70.28
General average of all determinations				—	—	70.21

TABLE 14

Respiration of turning lanzones at 27.5°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	Sept. 11	2.25	117.72	128.02	122.87
	2		1.00	110.23	120.94	115.59
	3		2.00	112.69	125.59	119.14
	4	12	1.00	80.71	92.00	86.36
	5		2.00	88.09	96.65	92.37
	6		3.50	85.77	96.57	91.17
	7		1.00	77.75	76.83	82.29
	8		1.00	79.72	92.00	85.86
	9		1.00	75.70	81.66	78.68
	10		1.00	79.72	78.54	79.13
Average				90.81	99.88	95.35
II	1	Sept. 14	1.00	124.67	149.92	137.30
	2		1.00	132.98	149.04	141.01
	3		1.00	130.90	150.78	140.84
	4		1.00	127.28	145.56	136.42
	5		1.00	121.55	140.33	130.94
	6	15	1.00	110.12	122.90	116.51
	7		1.00	104.93	127.77	116.35
	8		2.00	102.33	115.05	108.69
	9		2.50	104.30	110.87	107.59
	10		1.00	87.27	99.36	93.32
	11		2.00	94.54	102.41	98.48
Average				112.81	128.55	120.68
General average of all determinations				—	—	108.01

TABLE 15

Respiration of ripe lanzones at 0°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	Aug. 11	1.00	7.87	8.48	8.18
	2		3.00	8.91	8.41	8.66
	3		2.00	9.53	8.69	9.11
	4		2.00	9.11	8.79	8.95
	5		2.00	9.01	8.27	8.64
	6	12	14.00	9.26	8.42	8.84
	7		2.00	9.73	7.65	8.69
	8		1.75	8.40	7.68	8.04
	9		1.75	8.28	7.68	7.98
	10		2.00	8.08	7.44	7.76
Average				8.82	8.15	8.49
II	1	Aug. 19	1.50	7.58	7.72	7.65
	2	20	14.00	9.98	9.57	9.78
	3		2.17	9.35	8.73	9.04
	4		3.00	8.27	8.13	8.20
	5	21	14.00	7.84	7.75	7.80
	6		3.00	7.17	7.24	7.21
	7		3.00	6.82	7.24	7.03
	8		4.00	6.82	7.24	7.03
	9	22	14.00	6.25	6.36	6.31
	10		10.00	5.67	5.46	5.57
Average				7.58	7.54	7.56
General average of all determinations				—	—	8.02

TABLE 16

Respiration of ripe lanzones at 10°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	Aug. 19	2.00	17.81	15.32	16.57
	2		1.50	17.67	16.01	16.84
	3	20	4.00	16.98	15.43	16.21
	4		3.00	16.43	13.94	15.19
	5	21	3.00	17.67	16.01	16.84
	6		4.00	16.46	14.70	15.58
	7	22	3.50	17.16	15.50	16.33
	8		3.50	18.22	17.04	17.63
Average				17.30	15.49	16.40
II	1	Aug. 24	2.00	20.90	20.06	20.48
	2		1.75	20.10	20.12	20.11
	3		2.00	20.44	19.32	19.88
	4		1.00	15.52	15.95	15.74
	5		2.00	20.23	18.83	19.53
	6		1.50	19.80	18.23	19.02
	7	25	2.00	20.95	22.11	21.53
	8		2.00	21.99	21.57	21.78
	9		1.00	20.20	19.16	19.68
	10		1.00	21.21	20.61	20.91
	11		1.00	22.04	20.82	21.43
	12		1.00	20.80	21.03	20.92
Average				20.35	19.82	20.09
General average of all determinations				—	—	18.24

TABLE 17

Respiration of ripe lanzones at 20°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	Aug. 24	1.75	55.09	52.72	53.91
	2		2.00	55.48	52.78	54.13
	3		2.00	55.06	50.32	52.69
	4		1.50	52.78	52.50	52.64
	5	25	2.00	44.26	44.33	44.30
	6		2.00	45.71	47.79	46.75
	7		2.00	46.23	44.15	45.19
	8		1.00	44.67	45.92	45.30
	9		1.00	48.00	47.17	47.59
	10		1.00	46.75	46.75	46.75
	11		1.00	48.00	46.75	47.38
Average				49.28	48.29	48.78
II	1	Sept. 1	1.00	29.58	31.34	30.46
	2		1.00	30.27	30.04	30.16
	3		1.00	34.40	32.65	33.53
	4		1.00	33.02	30.69	31.86
	5		1.00	33.68	32.00	32.84
	6		1.00	31.65	32.00	31.83
	7		1.00	33.30	32.65	32.98
	8		2.00	31.99	31.67	31.83
	9	2	1.00	30.27	28.73	29.50
	10		1.00	28.89	28.73	28.81
	11		2.50	30.82	31.61	31.22
	12		2.00	30.27	32.32	31.30
Average				31.51	31.20	31.36
III	1	Oct. 1	1.00	39.25	38.66	38.96
	2		1.00	39.60	41.49	40.55
	3		1.50	47.66	46.34	47.00
	4		2.00	55.19	53.02	54.11
	5		2.00	49.76	48.76	49.26
	6		1.00	41.00	42.20	41.60
	7	2	1.00	36.44	42.08	39.26
	8		1.00	40.30	42.20	41.25
	9		2.00	45.38	45.57	45.48
	10		1.75	45.05	44.59	44.82
	11		3.50	47.26	46.71	46.99
Average				44.26	44.69	44.48
General average of all determinations				—	—	41.54

TABLE 18

Respiration of ripe lanzones at 27.5°C.

SET NO.	TITRATION NO.	DATE	HOURS DURATION OF EXPERIMENT	MILLIGRAMS CO_2 PER KILOGRAM HOUR		
				Sample 1	Sample 2	Average of samples 1 and 2
		1931				
I	1	July 28	1.00	48.70	64.42	56.56
	2		1.00	43.66	59.17	51.42
	3		1.50	51.89	54.40	53.15
	4		1.00	54.29	61.43	57.87
	5		1.00	60.74	59.43	60.09
	6		1.00	52.39	60.30	56.35
	7	29	1.00	49.35	55.45	52.40
	8		1.00	50.11	52.81	51.46
	9		1.00	49.35	52.43	50.89
	10		1.00	48.98	52.42	50.70
	11		2.25	62.42	61.03	61.73
Average				51.99	57.57	54.78
II	1	Aug. 10	1.00	90.87	94.14	92.51
	2		1.50	89.22	90.68	89.95
	3		1.00	89.22	88.75	88.99
	4		1.00	88.81	84.19	86.50
	5		1.00	80.13	81.29	80.71
	6		1.50	85.92	86.81	86.37
	7	11	1.00	62.37	67.60	64.99
	8		1.00	66.91	66.70	66.81
	9		2.00	72.23	78.03	75.13
	10		2.00	69.81	73.61	71.71
	11		2.00	68.57	72.58	70.58
Average				78.55	80.40	79.48
III	1	Oct. 4	1.00	87.37	—	—
	2		1.00	84.88	—	—
	3		1.50	84.54	—	—
	4		2.00	92.61	—	—
	5		2.00	88.87	—	—
	6		1.00	80.88	—	—
	7	5	1.00	67.90	—	—
	8		1.00	68.90	—	—
	9		2.00	72.04	—	—
	10		1.75	71.04	—	—
Average				79.96	—	—
General average of all determinations				—	—	69.70

TABLE 19

Influence of maturity on catalase activity of the rind

SAMPLE NO.	NUMBER OF DETERMINATIONS	TIME REQUIRED TO LIBERATE 1, 2, AND 3 CC. OF OXYGEN		
		1 cc.	2 cc.	3 cc.
		seconds	*seconds*	*seconds*
		Green		
1	a	16	28	47
	b	18	30	54
2	a	13	23	37
	b	13	23	40
3	a	16	32	51
	b	14	25	42
4	a	17	28	47
	b	17	29	49
5	a	20	30	40
6	a	13	19	29
	b	13	20	32
7	a	13	22	31
	b	13	21	32
8	a	13	21	31
	b	9	16	25
9	a	14	22	35
	b	8	13	19
10	a	13	21	30
	b	13	21	31
Average	—	14	23.37	36.95
		Turning		
1	a	15	22	31
	b	13	18	26
2	a	12	16	22
	b	12	16	22
3	a	11	15	21
	b	12	10	21
4	a	13	18	27
	b	12	18	28
5	a	12	19	28
	b	13	19	29
Average	—	12.50	17.10	25.50
		Ripe		
1	a	20	30	47
	b	18	33	52
2	a	16	27	41
	b	17	27	40
3	a	22	40	58
	b	25	42	62
4	a	13	20	28
	b	13	20	28
5	a	21	32	44
	b	22	32	43
Average	—	18.70	30.30	44.30

TABLE 20

Certain chemical changes in lanzones stored at different temperatures

STORAGE TEMPERATURE	NUMBER OF DAYS IN STORAGE	SAMPLE NUMBER	DRY WEIGHT	SPECIFIC GRAVITY	TITRATABLE ACIDITY	AMOUNT OF SUGARS ON FRESH WEIGHT BASIS	
						Reducing	Total
			per cent		*normality*	*per cent*	*per cent*
	At the beginning	1	20.15	1.063	.280	9.796	13.662
		2	19.97	1.064	.281	9.840	13.521
		Average	20.06	1.064	.281	9.818	13.592
0°C.	5	1	19.15	1.110	.261	9.465	11.294
		2	19.04	1.072	.261	9.493	11.154
		Average	19.10	1.091	.261	9.497	11.224
10°C. to 13°C.	14	1	19.34	1.070	.299	9.453	13.523
		2	19.77	1.070	.301	10.195	12.749
		Average	19.56	1.070	.300	9.824	13.136
13°C. to 15.5°C.	10	1	19.43	1.069	.271	10.447	13.414
		2	19.37	1.070	.273	10.335	13.357
		Average	19.40	1.070	.272	10.391	13.386
	19	1	19.01	1.075	.222	10.516	13.884
		2	18.73	1.075	.222	10.400	13.948
		Average	18.87	1.075	.222	10.458	13.916
16°C. to 18°C.	10	1	18.92	1.073	.245	8.982	12.672
		2	19.08	1.073	.244	8.818	12.890
		Average	19.00	1.073	.245	8.900	12.781
	19	1	18.67	1.070	.226	9.887	13.674
		2	17.93	1.070	.219	9.745	13.461
		Average	18.30	1.070	.223	9.816	13.568
20°C. to 22°C.	8	1	17.95	1.067	.263	9.173	11.111
		2	17.99	1.066	.266	9.173	11.111
		Average	17.97	1.067	.265	9.173	11.111
	14	1	17.44	1.062	.227	7.093	10.537
		2	17.42	1.062	.222	7.056	10.463
		Average	17.43	1.062	.225	7.075	10.500
27°C. to 27.5°C.	7	1	18.78	1.074	.231	7.757	12.830
		2	18.97	1.064	.231	7.822	12.396
		Average	18.88	1.069	.231	7.790	12.613

A COMPARATIVE STUDY OF VARIOUS METHODS OF FEEDING CHICKS[1]

HILARION S. SAVELLA

WITH ONE CHART

The method of handling and caring for poultry during the early period of growth deserves the special attention of poultry raisers, because it is during this period that chicks get their start and the profit derived from them when marketed depends to a certain extent upon their size and condition at weaning time. Any retardation in the rate of growth following improper feeding methods makes the chicks susceptible to unfavorable conditions. While the chicks may be fed in various ways, the question arises, which method will give the most satisfactory results? The experiments here reported were carried out with the object of throwing some light on this subject. These experiments were conducted from May, 1934 to January, 1935.

REVIEW OF LITERATURE

According to Kennard and Bethke (1926), the customary procedure of feeding chicks, that is, the giving of different grain and mash mixtures, the proportions of each being changed at various times depending on the age of the chicks, results in much confusion and uncertainty. The same authors stated that since 1922, in experimental tests at the Ohio Experiment Station, the chicks used received all-mash and no scratch grains. This method was used with very good results for all the chicks; they developed uniformly; there was low mortality during the brooding period; and the pullet mortality was especially low during the summer range period. The pullets from the all-mash fed chicks were of good weight, fairly uniform, vigorous and there were very few culls.

Amon (1930) observed that chicks that were self-fed with grain and mash in which the proportion of grain to mash was optional with the birds had a slight but consistently faster rate of growth than those that were fed free-choice where the ingredients were placed in separate receptacles and those in which the grain and mash were hand-fed in the proportion of 1 : 1. He also found that of the three methods of feeding studied, the free-choice fed birds consumed the most; and those that received grain and mash but with the proportion of grain and mash optional with the chicks, consumed the least. He further noted that there was practically no difference in the mortality among the chicks in the different methods of feeding studied.

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[1] Thesis presented for graduation, 1935, with the degree of Bachelor of Science in Agriculture from the College of Agriculture, No. 504; Experiment Station contribution No. 1137. Prepared in the Department of Animal Husbandry under the direction of Dr. F. M. Fronda.

Green (1921) stated that the feeding of dry-mash is a better practice than feeding of wet or moist mash as dry-mash feeding requires less work and the chicks can regulate their feed to suit their needs. But wetting the mash with water or with milk is a common practice among many poultrymen. Lippincott and Card (1934) do not recommend this practice except in cases where the additional expense of labor is compensated for by the better results in production, and this is always doubtful. The additional work in this method is the wetting of feed, spreading it in the trays and cleaning them from time to time. The sole advantage mentioned in favor of this method is the increased palatability of the feed.

Lippincott and Card (1934) also stated, however, that poultrymen are not agreed on the relative merits of wetting all or a part of the feed or feeding it all dry. They stated that the results of experiments point to dry feeding being the better. Among the advantages of this method, as given by these authors are: (1) the feed may be hopper-fed, (2) labor cost lessened, (3) avoidance of mobbing or puddling common in the wet-mash feeding when the birds are fed in trays or troughs, (4) chicks fed by this method are more evenly fed than those receiving wet-mash where the more vigorous ones gorge themselves and the weak ones go hungry, and (5) when rigid sanitation is required, the all-mash method is superior to the grain and mash feeding.

There appears to be no experiments on feeding cooked mash to chicks. In swine, however, it has been observed that when rapidity and economy of gain is desired, feeding uncooked feed is better than feeding cooked (Bolivar, 1928). Henry and Morrison (1926) stated that, in general, cooking either grain or roughage does not increase its digestibility or nutritive value and may even decrease the digestibility of the protein. They further stated that several tests at various experiment stations showed conclusively that there was, in most cases, an actual loss rather than a gain from cooking feed for swine.

PLAN OF THE STUDY

Los Baños Cantonese chicks, artificially hatched from eggs produced by the College flocks, were used in these experiments. There were three sets of trials of five lots each. In the first set, there were 59 chicks to a lot, in the second, there were 27, and in the third there were 31. There was, therefore, a total of 117 chicks for the three sets.

The same kind of ration was used in all the lots. It consisted of the following ingredients, all parts by weight:

Rice bran	56.25 parts
Corn meal	18.75 "
Shrimp meal	25.00 "

The chemical analyses of the feeds as determined by the Department of Agricultural Chemistry, College of Agriculture, are as follows:

CONSTITUENT	RICE BRAN	CORN MEAL	SHRIMP MEAL
	per cent	*per cent*	*per cent*
Moisture	9.20	12.48	14.55
Ash	10.11	1.54	19.73
Crude protein	12.38	9.37	55.61
Crude fiber	9.72	1.93	4.24
Nitrogen free extract	44.70	69.77	3.26
Crude fat	13.89	4.91	2.61
Total	100.00	100.00	100.00

The different lots were fed as follows:

LOT NO.	CONDITION OF THE RATION
1	Grain and mash; grain was hand-fed; mash dry, uncooked, self-fed.
2	All-mash; dry, uncooked, self-fed.
3	All-mash; dry, uncooked, hand-fed.
4	All-mash; wet, uncooked, hand-fed.
5	All-mash; cooked, hand-fed.

The chicks were raised in fireless brooders placed in grassy yards. Except in lot 1 (grain and mash lot) where the grain was given for scratch, all the mash feeds were placed in wooden feeding troughs kept open to the chicks at all times during the day. Fresh cool water was available in bamboo drinking troughs to all the chicks.

Records. The chicks were weighed when one day old and every seven days thereafter up to the twelfth week. Observations were made on the health, vigor and condition of the chicks in each lot. Records were also made of the amount of feeds consumed, and on the mortality of the chicks.

RESULTS AND DISCUSSIONS

Rate of growth. The weekly weights of the chicks are given in table 1 and graphically presented in chart 1. By reference to this table and chart, it may be seen that the chicks in each lot weighed about the same at the beginning of the experiment.

In the fourth week, some variations in the average size of the chicks in the different lots became noticeable, those in lots 2, (all mash, dry, uncooked and self-fed), 3 (all-mash, dry, uncooked, and hand-fed), and 4 (all-mash, wet, uncooked, and hand-fed) being larger than those in lots 1, (fed grain and mash, the grain hand-fed, and the mash fed dry, uncooked and self-fed) and 5, (all-mash, cooked, and hand-fed). At the age of eight weeks, the chicks in lot 2 were significantly larger than those of the other lots, and those of the other lots, and those of lots 1 and 4, second in size. The chicks in lots 3 and 5 were the smallest at this age.

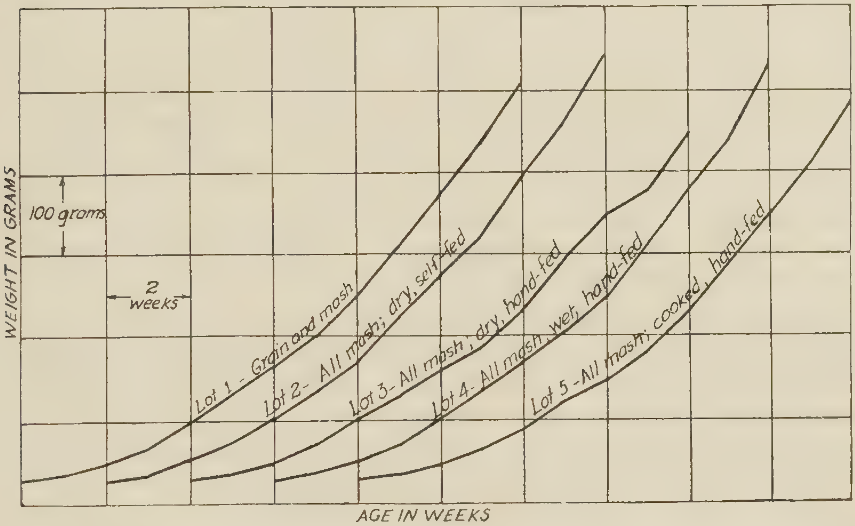

Chart 1.—Curves showing the relative rate of growth of the chicks in the different lots studied up to the age of 12 weeks.

At the close of the feeding trial at 12 weeks of age, the effects of the different systems of feeding tried were more marked. The chicks in lot 1 weighed 510.6 ± 10.038 grams; those in lot 2, 548.4

± 9.678 grams; those in lot 3, 448.7 ± 10.770; those in lot 4, 530.6 ± 8.447 grams; and those in lot 5, 491.0 ± 15.000 grams. Some of the lots differed significantly in weight at this age: lot 2 was heavier than lot 3 by 99.7 ± 14.480 grams; lot 5 was lighter than lot 2 by 57.4 ± 17.851 grams; lot 3 was lighter than lot 1 by 61.9 ± 14.722 grams; and lot 3 was lighter than lot 4 by 81.9 ± 13.119 grams.

It might be stated here that in the three feeding trials, the lot 2 chicks (all mash, dry uncooked, self-fed) were the heaviest in each set; the grain and mash lot (lot 1) ranked twice in the third place and once in the second; lot 3 (hand-fed) receiving all-mash, uncooked, was always the lightest; lot 4 ranked once in the second, fourth, and third places; and lot 5 (cooked-mash) ranked twice in the fourth place and once in the second place.

It was observed that in lot 4 (wet mash), the chicks trampled in the feed troughs and thus made the wet feed more difficult for them to pick up than when it was dry. The same difficulty was encountered in the cooked-mash lot. That the chicks fed cooked-mash did not grow as fast as those fed uncooked may be because in the cooking the digestibility of the proteins may be decreased (Henry and Morrison, 1929). This result from feeding cooked feed corroborates Bolivar's (1928) observations with pigs.

The chicks that received the grain separate from the mash did not eat as eagerly as those of the all-mash lots after they had finished the grain part of their ration. For this reason, less feed was consumed and a corresponding slower growth resulted. Similarly, in the hand-fed lot, the chicks fed dry mash had relatively less consumption and therefore their slower growth was expected.

The amount of feed consumed. By reference to table 2, the amount and cost of feeds charged per 100 birds may be seen. The birds in lot 5, fed all-mash cooked, consumed the most feed, and the hand-fed chicks, lot 3, consumed the least. That the birds receiving cooked mash consumed more feed than those receiving uncooked mash may be attributed to its very appetizing flavor. The birds in lot 1 (grain and mash lot) could not eat as much as the birds in the dry, all-mash lot because while the chicks in the grain and mash lot ate the grain part of the ration with marked greediness and haste, they took the mash portion with less eagerness than did those of the all-mash lots. The chicks in lot 3 (hand-fed) ate the least because, although they ate their ration with greediness, they could not fill their crops as readily as those of the self-fed lot, as a less amount could be picked up each time. The amount of feed calculated to last chicks in the self-fed lots for a day was divided into five parts and given in separate amounts to the hand-fed lot receiving dry, all-mash, but the chicks were not able to finish all of it. Hence, the chicks in this lot were never entirely without feed during feeding intervals. Despite the increased palatability in lot 4 from wetting the feed, there was a disadvantage as the feed became caked when the chicks trampled on it. This necessitated crumbling the clubbed particles once in a while. Another drawback in giving wet-mash was that when feces dropped on the feed, the ration became very dirty. The same was true in the cooked mash. In the dry-mash lot, there was no mobbing of feed, and any manure that dropped on the feed was enveloped by the particles of the mash which could then be easily removed.

Returns above feed cost. The returns above the feed cost in the different lots, computed by substracting the cost of feed from the value per 100 birds calculated at ₱0.60 a kilogram, are shown also in table 2. Lots 2 and 4 gave the largest returns, ₱13.07 for lot 4, and ₱13.05 for lot 2; lot 1 was second, with ₱12.50; lot 3, third with ₱10.59, and lot 5 the smallest with ₱7.31. For cooking the feed, the total cost of the petroleum used at ₱1.45 a can, was ₱6.20. Deducting this sum from ₱7.31, there is only ₱1.11 left. This calculation did not take into account the cost of labor and the use of materials involved in the preparation of the feed. It took, on an average, about six minutes daily to prepare the feed to be cooked. To prepare the feed for the wet-mash lot required two to three times the labor that the dry-mash lot did, besides the time spent in crumbling the clubbed feed. The all-mash, uncooked, dry and hand-fed, took about 10 minutes daily to prepare, while the dry mash self-fed lot required only about 3 minutes. The grain and mash lot required a little more time than the dry-mash self-fed lot.

Mortality. The percentage of mortality for the first, second, and third sets and the averages in the respective lots are presented in table 3. This table shows that lot 5 had a high mortality with an average of 45.02 ± 1.168 per cent; lot 4, receiving wet-mash, contrary to expectations, had the lowest mortality in all the lots, except in the first set. The average mortality in this lot was 28.54 ± 1.799 per cent. The percentages for the other lots lie between these two extremes.

Except during the first set when the grain and mash lot had a mortality of 23.73 per cent, all the other sets had a relatively high mortality. Lot 3 (hand-fed receiving all-mash and dry, uncooked) had a high mortality except in the first set when the mortality was only 27.12 per cent. In the three trials the all-mash fed lot had about the same death toll as in the grain and mash lot and hand-fed lot. Fronda and Kabigting (1935) who first used the same kind and proportion of feeds as used in this study reported a mortality of only 16.99 ± 2.1743. The difference may be attributed to changes in environmental factors and other conditions. During the course of this study four storms occurred, and rainfall was relatively heavy and well distributed. There were less rainfall and no storms when Fronda and Kabigting carried on their experiment.[2]

Minor observations. There was no appreciable difference in the health, vigor and development of combs and feathers of the chicks in lot 1 (grain and mash) lot 2, (all-mash dry, uncooked, self-fed) and lot 4, wet-mash. The chicks in lot 3 and lot 5 were not as vigorous as the self-fed ones. The hand-fed chicks that received uncooked dry-mash (lot 3) were the tamest of the birds in all the lots. Likewise, the hand feeding of the grain part of the ration in lot 1 made the birds relatively much tamer than those in the all-mash self-fed lots. The self-fed chicks receiving all-mash, fed dry and uncooked, were the wildest of all the chicks. They were so wild that many of them ran away when the feed was being placed in the fed troughs.

The chicks in lot 3 (all-mash, dry, uncooked, hand-fed) were observed to stop eating only at the approach of darkness in the evening, but the self-fed birds stopped picking up the feed even before the sun set. It was also observed that the cooked mash fed chicks had more desire to eat grass than those in any of the other lots. This was very apparent in the first set when there were 59 chicks to a lot, for the chicks in lot 5 grazed the grass to the ground in their yard earlier than in any of the other lots.

SUMMARY AND CONCLUSIONS

The effect of the various methods of feeding growing chicks was studied. From the results obtained the following summary and conclusions are presented:

1. The chicks fed either wet-mash or grain and mash, and those that received all-mash but self-fed were more vigorous, more rapid growers and with less mortality than those fed cooked mash or uncooked-mash but hand-fed.

2. The cooked-mash fed chicks consumed the most; those given dry uncooked feed, but hand-fed, ate the least.

3. The highest mortality, 45.02 per cent, occurred in the cooked-mash fed lot; the lowest, 28.54 per cent, in the wet-mash lot.

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[2] Data secured from the "Weather Observations at the College of Agriculture" filed in the Department of Plant Physiology.

4. The chicks in the grain and mash lot, and those in the all-mash, dry hand-fed lot were the tamest of all the birds; those in the all-mash, dry but self-fed were the wildest.

5. Of all the methods of feeding tried, the self-feeding of all-mash, dry, was the best.

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TABLE 1

Showing the mean weights of the chicks during the first twelve weeks after hatching

AGE	LOT 1		LOT 2		LOT 3		LOT 4		LOT 5	
	Number of chicks	Grain and mash grain, hand-fed mash dry, uncooked, self-fed	Number of chicks	All-mash, dry uncooked self-fed	Number of chicks	All-mash, dry uncooked hand-fed	Number of chicks	All-mash, wet uncooked hand-fed	Number of chicks	All-mash cooked hand-fed
		grams		*grams*		*grams*		*grams*		*grams*
1 day old	117	30.0 ± 0.156	117	29.4 ± 0.166	117	29.8 ± 0.173	117	29.6 ± 0.162	117	29.1 ± 0.173
1 week	110	35.2 ± 0.331	109	35.4 ± 0.391	109	34.8 ± 0.339	107	36.1 ± 0.339	103	34.0 ± 0.242
2 weeks	101	49.3 ± 0.738	100	51.0 ± 0.766	102	49.1 ± 0.829	102	50.2 ± 0.732	96	47.3 ± 0.725
3 weeks	100	68.5 ± 1.197	99	71.9 ± 0.103	96	71.9 ± 1.519	102	70.2 ± 1.180	95	65.0 ± 1.313
4 weeks	96	97.6 ± 1.996	96	102.2 ± 2.018	91	101.8 ± 2.386	99	101.0 ± 1.860	84	89.1 ± 2.036
5 weeks	94	132.9 ± 2.534	93	134.4 ± 2.485	85	129.0 ± 2.456	98	135.8 ± 2.435	76	120.9 ± 2.911
6 weeks	86	164.8 ± 2.790	86	168.3 ± 3.106	77	159.1 ± 4.091	94	170.0 ± 3.242	73	148.0 ± 3.957
7 weeks	81	201.3 ± 3.559	83	220.0 ± 4.104	74	185.3 ± 4.752	93	207.5 ± 3.669	64	183.1 ± 5.026
8 weeks	79	249.9 ± 5.606	82	269.9 ± 5.440	71	232.1 ± 5.825	87	249.3 ± 4.518	61	234.7 ± 6.754
9 weeks	79	309.1 ± 6.574	81	314.4 ± 5.939	70	290.8 ± 6.539	84	313.2 ± 5.358	61	289.8 ± 8.577
10 weeks	79	374.7 ± 8.332	79	391.8 ± 7.715	70	345.0 ± 7.506	82	382.2 ± 6.340	60	350.1 ± 10.156
11 weeks	79	430.3 ± 8.257	79	454.1 ± 8.663	70	375.3 ± 8.474	81	436.6 ± 7.360	57	409.1 ± 12.118
12 weeks	79	510.6 ± 10.038	74	548.4 ± 9.678	68	448.7 ± 10.770	80	530.6 ± 8.447	56	491.0 ± 15.000

TABLE 2

Showing the amount of feed charged, and returns above feed costs in the different lots on the basis of 100 birds

LOT NO.	TREATMENT	WEIGHT OF 100 BIRDS	VALUE OF BIRDS PER 100	AMOUNT OF FEEDS	COST OF FEEDS PER 100 BIRDS	RETURNS ABOVE FED COST
		kgm.	*pesos*	*kgm.*	*pesos*	*pesos*
1	Grain and mash grain, hand-fed, mash dry, uncooked, self-fed	51.06	30.64	271.52	18.14	12.50
2	All-mash, self-fed dry, uncooked	54.84	32.90	297.16	19.85	13.05
3	All-mash, dry uncooked, hand-fed	44.87	26.92	244.41	16.33	10.59
4	All-mash, wet, uncooked, hand-fed	53.06	31.84	281.00	18.77	13.07
5	All-mash, cooked hand-fed	49.10	29.46	331.61	22.15	7.31

TABLE 3

Showing the percentage of mortality of the chicks (12 weeks old) during the first 12 weeks

LOT NO.	TREATMENT	SET			AVERAGE
		1st	2nd	3rd	
		per cent	*per cent*	*per cent*	*per cent*
1	Grain and mash grain, hand-fed mash dry, uncooked, self-fed	23.73	48.15	35.48	35.79 ± 4.755
2	All-mash, self-fed dry, uncooked	30.51	48.15	32.25	36.97 ± 3.771
3	All-mash, dry uncooked, hand-fed	27.12	55.60	35.48	39.40 ± 5.693
4	All-mash, wet uncooked, hand-fed	33.90	25.93	25.81	28.54 ± 1.799
5	All-mash, cooked hand-fed	49.15	40.74	45.16	45.02 ± 1.168

A REVIEW: "CITRUS DISEASES AND THEIR CONTROL"[1, 2]

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In 1926, the writer reviewed the first edition of "*Citrus diseases and their control*" by HOWARD S. FAWCETT AND H. ATHERTON LEE, published by McGraw-Hill Book Company, Inc., September, 1925. This review appeared in *The Philippine Agriculturist* 15: 385. 1926.

The second edition of this book, also published by McGraw-Hill Book Company, Inc., appeared in April, 1936. This edition of "*Citrus diseases and their control*", prepared by the senior author, is a thorough revision of the first edition. The materials have been entirely rewritten and many additional results of research on citrus diseases obtained during the past decade have been incorporated. Because of the vast authoritative information contained in it, the book is not only of importance and value to citrus orchardists, but it is also indispensable to students and investigators.

As in the first edition the book is divided into four parts. Part I contains 105 pages. In this part of the book, the rise and development of investigations on diseases of citrus is treated. It takes one as far back as 1884, when scientific work on citrus diseases began. A new chapter is devoted to species and varieties of citrus and their relation to diseases. The classes and types of citrus diseases, their world-wide distribution, the conditions that influence the severity of diseases, the general principles for preventing and treating citrus diseases, the protective materials used for spraying, disinfecting and dressing wounds, as well as the cultural operations that influence the incidence and distribution of citrus diseases are discussed in Part I.

Part II contains 114 pages of discussion of the diseases of the roots and trunk. Part III has 146 pages dealing with the diseases of branches, twigs, and leaves. Part IV is a discussion of all known diseases of the fruits. The section on the control of blue and green molds of citrus fruits has been thoroughly revised. Professor Fawcett devoted 214 pages to the discussion of diseases of the fruit. At the

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[1] FAWCETT, HOWARD S. 1936. Citrus diseases and their control. 2nd ed. xv + 656 p., 187 fig. New York: McGraw-Hill Book Company, Inc.

[2] General contribution from the College of Agriculture No. 531.

beginning of each of the parts there is a key for the diagnosis of diseases.

A very important addition to Part III of the second edition is the chapter on diseases caused by deficiency or excess of inorganic constituents. This chapter was written by Professor Fawcett in collaboration with Dr. A. R. C. Haas also of the University of California. The inorganic constituents that affect citrus when they are either in excess or deficient are:

1. nitrogen
2. carbon
3. oxygen
4. phosphorus
5. potassium
6. zinc
7. iron
8. calcium
9. manganese
10. magnesium
11. aluminum
12. boron
13. chlorine
14. sulfate
15. hydrogen ion
16. copper

The substances that affect citrus when present in excess are:

1. sodium: as chloride and as nitrate
2. arsenic: no injury in small amounts
3. lithium: in culture solutions injurious when present in the proportion of 1:1,000,000
4. chromium: as potassium chromate injurious
5. beryllium: very toxic

Remedial measures are given for:

1. boron either deficient or in excess
2. chlorine in excess
3. sulfate either deficient or in excess

In the absence of phosphorus, silica is beneficial to lemon cuttings in culture solutions.

The important new information in the second edition of the book includes evidences that citrus canker may have originated somewhere in India or Java; the virus nature of psorosis; and the *Fusarium* twig disease of citrus caused by *Fusarium solani* (Mart.) Appel and Wollenw., occurring in Egypt and in the Philippines. Professor Fawcett has also added new information on leprosis, melanose, red blotch, peteca, mottle-leaf, foot rot and scab.

Twenty-two new sections have been added to the second edition. Some of the new sections were written by Professor Fawcett in collaboration with various specialists. For example, the new sections on sweet-orange fruit scab, Australian citrus scab and areolate spot were written in collaboration with Dr. Anna E. Jenkins of the United States Department of Agriculture. The section on citrus blight was written in collaboration with Dr. A. S. Rhoads of the Florida Agricultural Experiment Station. The new sections added to the second edition are as follows:

1. mal secco
2. water rot
3. areolate spot
4. bark blotch
5. sweet-orange fruit scab
6. Australian citrus scab
7. Valencia rind spot
8. rind breakdown
9. *Clitocybe* root rot
10. hard root rot
11. *Macrophomina* root rot
12. infectious mottling
13. zonate chlorosis
14. *Ascochyta* blight
15. cotton root rot
16. red root disease
17. *Ganoderma* root rot
18. xyloporosis
19. little-leaf
20. mesophyll collapse
21. Bordeaux injury
22. minor root rots

This book is the most complete treatise on diseases of citrus known, not only in the United States, but the world over. It is written in such an authoritative manner that only a man of Professor Fawcett's experience on citrus diseases can present. The book is illustrated with 187 text figures, 15 of which are colored plates. It has a bibliographic list of about 1054 titles.

COLLEGE AND ALUMNI NOTES

Camp Henry T. Allen, Baguio, is generously represented by College alumni who are undergoing military training after receiving their commissions as probationary third lieutenants: Marcelo Garcia, '31, Proceso E. Alcala, '32, Francisco Isidoro, '32, Nicolas L. Gonzales, '32, Cornelio Mariano, '32, Valeriano Borja, '33, Onofre Casupang, '33, Arturo de los Reyes, '33, Juan P. Tecson, '33, Porfirio Carandang, '34, Melecio Duran, '34, Hugo Fernandez, '34, Gregorio Jaime, '35, and Ignacio Valentin, '36.

Serious outbreaks of armyworm, *Spodoptera mauritia* Boisduval, destroyed young rice seedlings on various experimental farms of the College in July. This year's infestation was the worst since 1925, when an equally notable invasion by this pest occurred.

At the regular monthly meeting of the Los Baños Biological Club on August 27 the following papers were read: (1) Dr. F. M. Fronda, Mr. F. T. Bañez, and Mr. G. A. Monegas—"The influence of withholding feeds from newly hatched chicks." (2) Dr. F. O. Santos, Mr. I. E. Villanueva, and Mr. José Silva—"On the foods of the families in Santa Catalina, Ilocos Sur, Paoay, Ilocos Norte, and Pototan, Iloilo." Doctor Santos presented the same paper at the scientific conference, National Research Council, Manila, August 28.

Miss Rosa F. Javier, A.B., M.A., University of the Philippines, M.A., University of Michigan, has been appointed temporary instructor in history at the Rural High School. Mis Javier was a holder of the Barbour Scholarship in 1926.

Mr. Agapito E. Buenaventura, '22, has recently been promoted to principal of the Catarman Agricultural High School from principal of Bañga Rural High School in Capiz.

The Ranchers' Club held its traditional annual barn dance on August 8. The gentlemen who attended dressed like farmers and the ladies wore their colorful *balintawak.*

The Senior Class Organization held its program and dance on September 5, with Major General Paulino Santos, of the Philippine Army, as the guest of honor. General Santos dwelt in his address on his plan to include vocational instruction in technical agriculture in the army training camps. Agricultural college graduates, according to him, will be assigned to every camp in order to help carry out this program.

Dr. I. Panlasigui read a paper on enrollment, entrance examination, and student elimination and Dr. M. Manresa, on the relation of research to the improvement of teaching, at the Los Baños faculty conference on the improvement of teaching, on August 17.

Dr. R. H. Le Pelley, entomologist, Department of Agriculture, Nairobi, Kenya, East Africa, arrived at the College campus on August 12, where he plans to spend about two months. Doctor Le Pelley is conducting a world-wide search for natural enemies of *Pseudococcus kenyae*, a serious pest of coffee in East Africa.

The Board of Regents of the University of the Philippines has recently appointed Prof. José E. Velmonte acting head of the Department of Agricultural Economics and Dr. Francisco M. Sacay acting head of the Department of Agricultural Education.

According to *Farm Research*, Dr. Otto A. Reinking has been appointed head of the division of plant pathology in the New York State Agricultural Experiment Station at Geneva, effective July 1, 1936, to fill the vacancy created by the retirement of Professor Fred Carlton Stewart. Doctor Reinking will be remembered as the foster father of our own department of plant pathology, which he organized during his connection with this College as professor of plant pathology from 1916 to 1921.

THE FARMER LOOKS TO THE WEATHER MAN [1]

When the present Weather Bureau was taken over as an official unit of the Philippine government after American occupation, its activities were in part directed along lines that were strictly and essentially agricultural. Hence, pending the establishment of a bureau of agriculture, the earlier monthly weather bulletins included, among others, reports on studies of insect pests and of parasitic insects by members of the Observatory staff. An important responsibility of the Weather Bureau as a basic agency in the promotion of Philippine agriculture has thus been given a timely expression.

The first typhoon announcement released by the Manila Observatory on July 7, 1879, is now a matter of history. It was not, of course, the earliest attempt at accurate weather forecasting. The Royal Society of London had been issuing official weather forecasts for Great Britain since 1865. And before that, Admiral FitzRoy had been releasing weather predictions, although at first this pioneer activity of the good admiral somewhat scandalized the Royal Society, which was then evidently skeptical about any such attempt. But for the Orient the Manila Observatory's feat was a novelty. The seemingly uncanny way in which Father Federico Faura predicted the direction and intensity of the coming typhoon quickly captured popular imagination, not only locally, but also in neighboring foreign countries. Hongkong, at its request, had the typhoon warnings transmitted there by cable from Manila beginning the following year, in 1880. The saving of life and property, and the resulting blessings to shipping, agriculture, and trade every year, cannot be gainsaid.

But agriculture has come to demand of a weather bureau a great deal more than a typhoon-forecasting service, valuable as this work is. The business of farming is being constantly reduced to the category of an exact science, where the element of chance is being gradually eliminated. Precise data are called for, not only on the crops and domestic animals themselves, but also in connection with the various surrounding factors the interplay of which has a fundamental bearing on production. The far-reaching rôle of climate in agricultural pursuits becomes at once apparent even to one who cultivates

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[1] General contribution from the College of Agriculture No. 532.

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a small vegetable garden patch or raises a few chickens in his backyard. As Merriam [2] noted years ago, in 1898, "most of these [crop] experiments result in disappointment and pecuniary loss. . . . If the crop happens to be one that requires a period of years for the test, the loss from its failure is proportionately great. The cause of failure in the great majority of cases is climatic unfitness. The quantity, distribution, or interrelation of heat and moisture may be at fault. Thus, while the total quantity of heat may be adequate, the moisture may be inadequate, or the moisture may be adequate and the heat inadequate, or the quantities of heat and moisture may be too great or too small with respect to one another or to the time of year, and so on. What the farmer wants to know is *how to tell in advance* whether the climatic conditions on his own farm are fit for the particular crop he has in view, and what crops he can raise with reasonable certainty."

In the Philippines itself, expensive mistakes, such as the 804 hectares planted to abacá in Ilocos Sur and 386 hectares in Ilocos Norte, recorded in the Census of the Philippine Islands for 1903, could have been avoided if a more careful consideration of climatological data had been made. These two provinces, for one thing, have a distinct dry season lasting from December to April, and no abacá could attain prosperous vigor through five months of protracted thirst. Likewise, the more recent misadventure in abacá planting in Laguna and Cavite can probably be traced to climatic cause, with the bunchy-top putting on the finishing touches. A further case in point was the ill-fated attempt at coconut planting on a large scale, not many years ago, in what is now the Diklom Ranch, on the semi-temperate high plateau of Bukidnon. With the present program of the government in crop diversification, numerous problems of a similar nature are bound to come up. These questions will most likely become intensified with the rapid opening for settlement of the sparsely populated, and very imperfectly known, parts of the country, such as the Mindanao interior. Numerous other phases of agricultural work, such as pest and disease control, are getting dependent to an increasing degree on detailed meteorological data.

A reliable description of the climate of any particular locality must represent an average of not less than thirty-five years of continuous weather observation. This premise is based on the fact that climatic features fluctuate appreciably from year to year, but this fluctuation tends to repeat itself every thirty-five years, approximately. Without implying criticism, when measured by this yardstick, only 35, out of 375, Weather Bureau stations will pass the test for rainfall, on which climatic factor data are the most extensive. Sixteen of the stations are situated in Luzon, only 2 of which are located in the agriculturally important Bicol Peninsula, 12 in eastern Visayas, 5 in Mindanao, 1 in Jolo, and 1 in Cuyo.[3] All, except six, had missing data in from a few to many months. To be fair, however, it must be pointed out that in this respect our own Weather Bureau would acquit itself with credit when compared with conditions obtaining in neighboring countries, such as China, with its area over thirteen times that of the Philippines and the population over twenty-three times as much. The following are the relative numbers of weather stations and years of rainfall observations. The figures for China have been kindly furnished by Father Selga.

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[2] MERRIAM, C. HART. 1898. Life zones and crop zones. U. S. Department of Agriculture, Division of Biological Survey, Bull. 10: 1-79. *1 map.*

Years of observation	*Weather stations*	
	Philippines	*China*
Less than 10	166	208
10-19	151	90
20-29	23	24
30-69	35	28
Total stations	375	350

In 1933, because of financial depression, the appropriation of the Weather Bureau was cut by one-half. The result was the closing of 120 weather stations, including five of those with very many years of observation. As a net outcome, there remained by 1936 only 46 official forecasting stations, distributed as follows:

	1st class	*2nd class*	*3rd class*	*Total*
Luzon	6	5	9	20
Eastern Visayas	3	3	10	16
Mindanao and Sulu	—	2	5	7
Palawan and Cuyo	—	—	3	3

This meager number, which is maintained primarily in the interest of typhoon-forecasting service, is obviously too inadequate to meet the needs of Philippine agriculture. Without any weather record, vast territories are left as blind spots where we may have to resort to hit-and-miss methods in farming. We cannot include in these figures the 133 rain stations, 125 of which are volunteer. The weather data needed in agriculture include, in addition to rainfall, at least temperature and atmospheric humidity. Moreover, the volunteer stations are dependent on the good-will of the coöperating individuals or institutions.

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[3] Data from SELGA, MIGUEL. 1935. Observations of Rainfall in the Philippines. 290 p. *118 pl.* Manila: Bureau of Printing.

It would seem, therefore, that in this country, which is fundamentally agricultural, a more liberal support of weather-observation activities is called for. If our forefathers fared along well enough without the aid of meteorological data in agriculture, it was because they were not confronted with the modern problems of world competition and rapidly thickening population. Besides, they could not have missed this essential tool, because they never had a chance to get acquainted with its use. Accumulation of suitable weather records is a painfully slow process. It involves an important element which is not within the power of man to hasten—time. Years hence, when our children or grandchildren shall have stepped into our shoes, they will most probably face a greater need for these data. Finding them wanting, they could not but feel resentful that they have been cheated of an opportunity, owing to our present generation's careless improvidence.

LEOPOLDO B. UICHANCO
Of the Department of Entomology

The bagauak, *Clerodendron quadriloculare* (Blanco) Merrill, an indigenous ornamental species, bursts into bloom on the College campus with the northeast trades, from November to February.

THE YIELD AND PRODUCTIVE LIFE OF NAPIER GRASS (PENNISETUM PURPUREUM SCHUM.) AS SOILAGE CROP FOR FARM ANIMALS [1]

VALENTE VILLEGAS
Of the Department of Animal Husbandry

The value of Napier grass for soiling purposes is evident, as has been shown in various trials, to wit: In feeding trials conducted by Paulino and Galang [2] using cattle, carabaos and horses, the palatability of Napier grass was satisfactory at 20, 30, 40 days of age. As the plant became older up to 90 days of age, the amount consumed decreased. It showed poorly in comparison with buñgalon (*Panicum stagninum* Retz.), Cayenne (unidentified species), Uba cane, Guatemala grass (*Tripsacum laxum* Nash.), Guinea grass (*Panicum maximum* Jacq.), Dallis (*Paspalum dilatatum* Poir.) and Para grass (*Panicum barbinode Trin.*). Pepa [3] found that for Philippine cattle, Napier grass is more palatable than either cogon or culape (*Paspalum conjugatum* Berg.), although less palatable than Guinea grass. Tuya [4], using horses, obtained fair results with Napier grass. He found it to be superior in palatability over culape and peanut hay and equal to sugar cane tops cut 1.3 cm. long. Guinea grass and barit (*Leersia hexandra* Siv.), however, showed to be more palatable than Napier grass. In trials with goats, Suratos [5] concluded that Napier grass, because of its superior palatability, is highly recommended for feeding both young and mature goats.

For many years the Department of Animal Husbandry of the College of Agriculture, University of the Philippines, has maintained areas of Napier grass as sources of green feed for its animals. Harvesting was made regularly at a stage of growth of the plants when they were suitable for feeding purposes. Two fields were set aside for close observation with a view of obtaining accurate information on the productive capacity of this species of grass as soilage crop.

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[1] Experiment Station contribution No. 1138. Received for publication July 13, 1936.

[2] GALANG, F. G., AND P. L. PAULINO. 1925. The Philippine Agric. Review 18: 3–31.

[3] PEPA, MAXIMO E. 1927. A comparative study of the palatability of some common Philippine forages. The Philippine Agriculturist 15: 547–555.

[4] TUYA, MANUEL. A comparative study of the palatability and proximate analysis of common forages for horses. (Thesis presented for graduation from the College of Agriculture 1930. Unpublished).

[5] SURATOS, FELICISIMO D. 1933. A study of the palatability and feeding value of some Philippine plants for goats. The Philippine Agriculturist 22: 202–218.

Specifically, the objects of this study were (1) to determine the yield of soilage harvested from fields of Napier grass throughout the different months of the year and (2) to find out the duration of life of the same fields during their productive period.

The work was conducted in the Department of Animal Husbandry of the University of the Philippines from October, 1930, to February, 1936.

CULTURES

As has already been referred to, two fields were used, namely, cultures A and B. Culture A had an area of 4,848.6 square meters and culture B, 5,143 square meters. The soil in culture A was deep loam and kept moist a great deal during the wet season because of its low elevation. In culture B, the soil was well-drained, friable loam with adobe sub-soil near the surface in about one-third the area.

Planting, Cultivation and Harvesting

Roostocks and stalks of Napier grass measuring about 20 cm. each were planted in hills about one meter each way in both cultures. One to three plants were placed in each hill. Furrows were run over the field and the plants were dropped and planted in them. The stalks were set on a slanting position about one-half of which being covered with soil. Planting was done on October 5, 1930, in culture A and from June 1 to 3, 1932, in culture B.

Whenever weeds were observed to gain foothold in the fields, cultivation was resorted to. Culape, Para grass, and cogon encroaching on the stand of Napier grass around the borders of the cultures were controlled by plowing.

Generally, the grass was cut when it had reached a height of about 120 cm. At this stage of development it was moderately fibrous and still juicy. Only a few scattering plants were in bloom at this time. During the dry season, because of insufficient moisture, the plants were stunted in growth and had to be harvested even if they were still short. The stalks were cut close to the ground and bundled together for weighing. The bundles were taken to the shed and weighed soon after harvesting to avoid much loss of weight.

DISCUSSION OF RESULTS

Yield

Culture A. Table 1 shows that heavy harvests were made for over three years in this field. During the year 1931 following the time of planting in October, 1930, the total yield was 28,931.3 kgm. which is equivalent to 59,656.4 kgm. a hectare. In 1932 the harvest was 8,268.9 kgm., or 17,050.4 kgm. a hectare, and in 1933, 8,139.6 kgm. or 16,783.9 kgm. a hectare. Harvesting was made throughout the year in 1931. The largest monthly crop was in July amounting to 7,727.4 kgm. (15,933.9 kgm. a hectare), the smallest in December which was 724.5 kgm. (1,493 kgm. a hectare). In 1932 the heaviest production of 2,456.6 kgm. (5,065.5 kgm. a hectare) was in October, but the following month in November the growth was so poor that no harvest was made. In the same manner, the largest yield recorded in 1932, which occurred in August, amounting to 4,667.5 kgm. (9,624.4 kgm. a hectare) was not followed by any harvest in September.

From June to November in 1931, the period of heavy rainfall, the yield was 19,649.2 kgm. (40,516.7 kgm. a hectare) which was 67.9 per cent of the total harvest for the year. In 1932, the crop during the same period was 6,643.7 kgm. (13,699.3 kgm. a hectare) representing 80.3 per cent of the year's production. The yield for the wet season in 1933, was 5,490.8 kgm. (11,322.0 kgm. a hectare), which is 67.5 per cent of the total amount collected throughout the year.

Taking the production during the first year, from the time of planting, in culture A, amounting to 24,636.5 kgm., as 100 per cent, it is clear that the total harvest during the second year which was 11,523.2 kgm. represented 46.8 per cent of the first year's harvest. During the third year, the yield was 10,069.6 kgm., or 40.9 per cent of the first year's production. Computing the yield during the last five months on one-year basis the production was 2,821.7 kgm. This is equivalent to 11.5 per cent of the first year's harvest.

The total yield of soilage cut during the period of productivity in this field was 47,405.0 kgm., or 97,749.1 kgm. a hectare. Computing the production by the year, the average annual harvest was 14,221.5 kgm., or 29,331.1 kgm. a hectare.

Culture B. Table 2 shows the production of culture B. The first year, in 1932, there was recorded half a year's harvest, from July to December, in this culture. The total yield was 16,173.7 kgm. (31,447.9 kgm. a hectare). The heaviest production amounting to 4,769.0 kgm. (9,272.8 kgm. a hectare) occurred in September while the lightest yield of 1,583.9 kgm. (3,079.7 kgm.) was harvested in October. Continuous monthly harvests were made in 1933 and 1934. In 1935, the field began to decline in production, more so towards the latter half of the year. In 1933, the total harvest amounted to 18,527.6 kgm. (36,019.5 kgm. a hectare). The monthly yield ranged from 388.3 kgm. (755.0 kgm. a hectare) in March to 4,513.7 kgm. (8,774.6 kgm. a hectare) in July. The following year, in 1934, the minimum monthly yield was 20.9 kgm. (40.6 kgm. a hectare) in October and the maximum was 2,600.0 kgm. (5,054.4 kgm. a hectare) in June. The total amount of soilage cut during the year was 12,924.3 kgm. (25,124.8 kgm. a hectare). The heaviest monthly harvest in 1935 was in May amounting to 1,303.6 kgm. (2,534.7 kgm. a hectare); no crop was obtained in August, October and November. The total yield of grass for the year was 4,642.4 kgm. (9,026.3 kgm. a hectare).

It is apparent that during the years of productive life of the grass, heavy production was obtained from 1932 to 1934, inclusive. In 1933, the yield during the wet season was 11,073.9 kgm. (21,527.6 kgm. a hectare) which is 60 per cent of the year's harvest. The yield for the same period in 1934 was 6,427.4 kgm. (12,494.8 kgm. a hectare), or 50 per cent of the production for the year.

The yield for one year from the date of planting in culture B was 22,829.1 kgm. In the second year, it was 17,905.1 kgm. This was 78.4 per cent of the first year's production. The third year's crop was 9,353.5 kgm. which is 41.0 per cent of the first year's crop. The yield during the last nine months, calculated on a year's basis, amounted to 4,724.7 kgm., or 20.7 per cent of the first year's harvest.

Altogether a total yield of 53,631.2 kgm. (104,269.1 kgm. a hectare) of soilage was cut from this culture throughout the whole period of productive life. The average yearly harvest amounted to 14,626.7 kgm. which is equivalent to 28,440.0 kgm. a hectare.

According to Wester,[6] in Cuba as much as over 550 tons of green feed were produced from a hectare of Napier grass in one year. Galang and Paulino presented records of production of Napier grass on an area of 144 square meters of non-irrigated field. Basing on a 100 per cent stand of the grass, the computed yield ranged from over 32 to about 170.5 tons of forage per hectare. The large yield was obtained from plants which were a little over five months old.

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[6] WESTER, P. J. 1920. Napier grass: A promising new forage plant for the Philippines. The Philippine Agric. Review 13: 353–354.

From an area of 330 square meters of irrigated land, the computed production from one hectare amounted to over 76 tons of grass. The last figure is based on the yield of plants which were four months younger than those from which about 170.5 tons of material were harvested.

Productive Life

From the date of planting to the time when the yield of forage was so low as to justify discontinuance of maintaining the field, the period was three years and four months in culture A. The productive life in culture B was three years and eight months. The average in the two cultures was three and a half years. During the last few months of the life of culture A, the stand of Napier grass was considerably reduced because of old age of the plants and the thick growth of culape, cogon and Para grass infesting the field. It was at this time that the field was discontinued. In culture B, Para grass also undermined the growth of Napier grass in places where the surface soil was deep. The rest of the field was practically free from weeds which partly accounts for the better stand of Napier grass and longer life of this culture over that in culture A.

SUMMARY

1. Yields of soilage from two cultures of Napier grass are presented, each culture with an area of approximately half a hectare. The soil in both cultures is loam, being low and deep in culture A and well-drained and rather shallow in culture B.

2. The average annual soilage crop in culture A was 14,221.5 kgm. which is equivalent to 29.3 tons a hectare. The range in annual production was from 8,139.6 kgm. (16.8 tons a hectare) to 28,931.3 kgm. (59.7 tons a hectare).

3. In culture B, the average yield a year was 14,626.7 kgm., or 28.4 tons a hectare. The smallest yearly crop was 4,642.4 kgm. (9.0 tons a hectare) the largest, 18,527.6 kgm. (36.0 tons a hectare).

4. During the wet season, from June to November, the production was 67.5 to 80.3 per cent of the yield for the year in culture A, and from 49.7 to 59.8 per cent in culture B.

5. During the first year from the date of planting the yield in culture A was 24.6 tons. Taking this as 100 per cent, the second year's production was 46.8 per cent, the third year's crop 40.9 per cent. On the basis of one year, the crop during the last five months was 11.5 per cent of the first year's harvest.

6. In culture B, the production during the first year from the time of planting was 22.8 tons. With this amount as the basis, the second year crop was 78.4 per cent and that of the third year 41.0 per cent. Computing the yield during the last nine months on one year basis, it amounted to 20.7 per cent of the first year's crop.

7. The total yield from culture A throughout the productive life of the plant was 47,405.0 kgm. (97.7 tons a hectare). From culture B, the total production was 53,631.2 kgm. (104.3 tons a hectare).

8. The productive life was on the average three years and a half in both cultures.

9. The yield declined as the age of the plants advanced. It was, however, seldom that no harvests were made each month.

TABLE 1

Monthly and yearly production of Napier grass in culture A

MONTH	1930		1931		1932		1933		1934	
	Actual	Per Ha.	Actual	Per Ha.	Actual	Per Ha.	Actual	Per Ha.	Actual	Per Ha.
	kgm.	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*
January			2,048.4	4,223.8	188.5	388.7	1,378.0	2,841.4	0.0	0.0
February			1,264.1	2,606.6	179.6	370.3	260.8	537.8	523.0	1,078.4
March			1,482.2	3,056.3	742.0	1,530.0	29.5	60.8	—	—
April			2,419.0	4,988.0	191.0	393.8	351.4	724.6	—	—
May			1,343.9	2,771.1	198.0	408.3	137.9	284.4	—	—
June			2,133.2	4,398.7	2,194.4	4,524.9	438.6	904.4	—	—
July			7,727.4	15,933.9	404.6	834.3	223.2	460.2	—	—
August			2,310.3	4,763.8	524.4	1,081.3	4,667.5	9,624.4	—	—
September			2,365.8	4,878.3	1,063.7	2,193.3	0.0	0.0	—	—
October			3,691.2	7,611.3	2,456.6	5,065.5	64.4	132.8	—	—
November	234.5	483.5	1,421.3	2,930.7	0.0	0.0	97.1	200.2	—	—
December	1,307.7	2,696.5	724.5	1,493.9	126.1	260.0	491.2	1,012.9	—	—
Total	1,542.2	3,180.0	28,931.3	59,656.4	8,268.9	17,050.4	8,139.6	16,783.9	523.0	1,078.4

TABLE 2

Monthly and yearly production of Napier grass in culture B

MONTH	1932		1933		1934		1935		1936	
	Actual	Per Ha.	Actual	Per Ha.	Actual	Per Ha.	Actual	Per Ha.	Actual	Per Ha.
	kgm.	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*	*kgm.*
January			2,381.3	4,631.1	744.7	1,447.7	495.8	963.8	0.0	0.0
February			1,138.5	2,213.7	1,760.8	3,423.0	138.8	269.8	1,363.2	2,650.6
March			388.3	755.0	1,465.1	2,848.2	321.6	625.2	—	—
April			1,137.9	2,212.5	934.4	1,816.5	202.3	393.4	—	—
May			1,608.9	3,127.7	1,127.9	2,192.6	1,303.6	2,534.7	—	—
June			1,743.2	3,398.5	2,600.0	5,054.4	390.1	758.5	—	—
July	2,143.2	4,167.2	4,513.7	8,774.6	1,985.8	3,860.4	1,039.1	2,020.4	—	—
August	4,403.1	8,561.3	2,536.4	4,542.0	1,110.4	2,158.6	0.0	0.0	—	—
September	4,769.0	9,272.8	692.2	1,345.6	354.7	689.5	508.0	987.8	—	—
October	1,583.9	3,079.7	1,148.4	2,232.5	20.9	40.6	0.0	0.0	—	—
November	1,681.9	3,270.3	635.0	1,234.4	355.6	691.3	243.1	472.7	—	—
December	1,592.6	3,096.6	798.3	1,551.9	464.0	902.0	0.0	0.0	—	—
Total	16,173.7	31,447.9	18,527.6	36,019.5	12,924.3	25,124.8	4,642.4	9,026.3	1,363.2	2,650.6

ALCOHOL AND ALCOHOL-GASOLINE BLENDS AS FUELS FOR AUTOMOBILE ENGINES: VI. STUDIES ON THE USE OF ALCOHOL-GASOLINE MIXTURES AS FUELS FOR A HIGH COMPRESSION EIGHT-CYLINDER AUTOMOBILE ENGINE[1]

A. L. TEODORO AND E. K. ONGSANSOY
Of the Department of Agricultural Engineering

WITH ELEVEN CHARTS

This study compares the performance curves of gasoline with those of alcohol-gasoline mixtures as fuels in an eight-cylinder automobile engine using high-compression heads.[2] The engine tested was a 1935 Ford V-8. Two sets of cylinder heads were used, one set giving a compression ratio of 6.3:1 and another giving a compression ratio of 7.5:1.

The fuels used were as follows:

(1) Gasoline—sp. gr. at 15°C. = 0.745.
(2) Mixture A—90 per cent gasoline + 10 per cent B-dehydrated alcohol.[3]
(3) Mixture B—80 per cent gasoline + 20 per cent B-dehydrated alcohol.
(4) Mixture C—60 per cent gasoline + 40 per cent alcohol motor fuel No. 9.[4]
(5) Mixture D—40 per cent gasoline + 60 per cent alcohol motor fuel No. 9.
(6) Mixture E—20 per cent gasoline + 80 per cent alcohol motor fuel No. 9.
(7) Mixture F—Alcohol motor fuel No. 9.

Two groups of tests I and II were made. Block tests were run in group I and road tests were carried out in group II. The procedure of test followed in group I was similar to that followed in all of the block tests reported by the senior author in "Alcohol and alcohol-gasoline blends as fuels for automotive engines" series I to V, inclusive. Speeds of 20 miles per hour, 25 miles per hour, 30 miles per hour, and 35 miles per hour were used in the road tests. The weight of the car was kept practically the same during the testing

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[1] Experiment Station contribution No. 1139. Received for publication July 22, 1936.

[2] Data on compression ratio were supplied by the Ford Motor Service representative.

[3] B-dehydrated alcohol—sp. gr. at 15°C. = 0.797. Alcohol strength of about 98.5 per cent by volume denatured with about 5 per cent sulfuric ether.

[4] Alcohol motor fuel No. 9—sp. gr. at 15°C. = 0.808. Alcohol strength of about 95 per cent by volume denatured with 5 per cent gasoline.

period. A driver, a recorder, and two passengers constituted the load of the car. The same driver and the same recorder were used in all of the tests.

The average of at least ten mileage readings taken with the use of a Zenith mileage tester was reported for each speed. The test was made on the asphalted highway between Calamba and Biñan, Laguna province. The running speed was kept as constant as possible. Few constant readings could be made at speed of 40 miles an hour on account of the traffic. Data when this speed was used were not reported because they were not reliable.

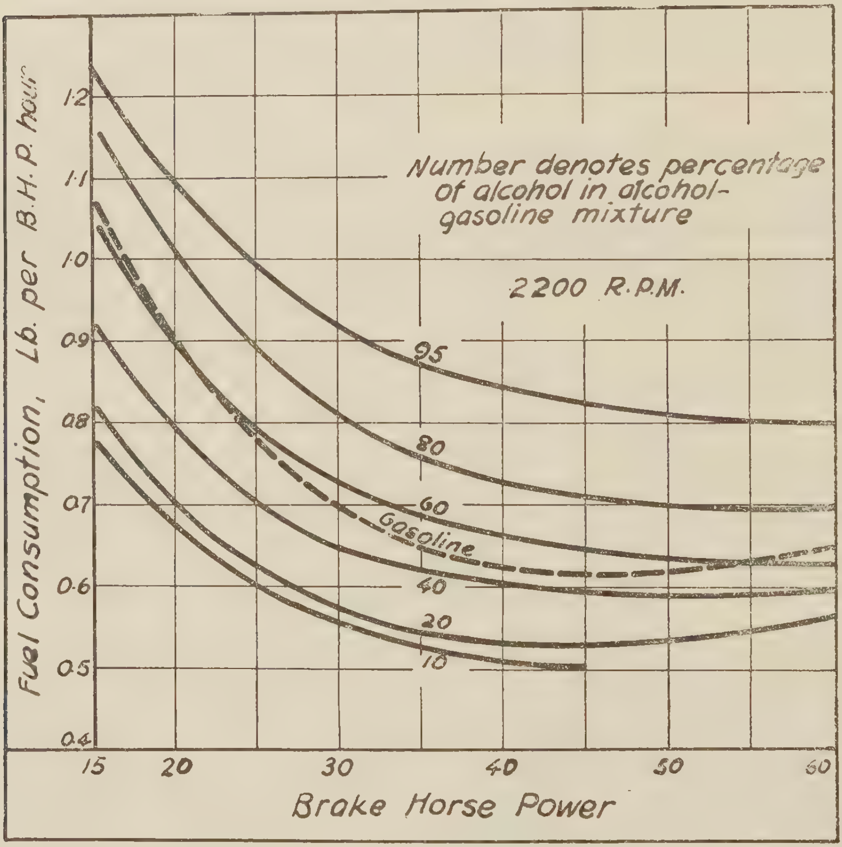

Chart 1.—Performance curves at 2200 R.P.M. (Number indicates percentage of alcohol in the mixture by volume.)

All the tests were carried out from October, 1935 to April, 1936.

PROCEDURE

Several preliminary block tests were run with gasoline to obtain performance curves which were nearly similar to the performance curves published by the Ford Motor Company for the Ford V-8 engine, with compression ratio 6.3:1. The adjustment that was used with gasoline was the same as that used in the mixture containing 10 per cent B-dehydrated alcohol for both groups I and II. Changes in the size of main jets, in idling adjustment, in spark advance, and in interrupter gaps were made when the engine was run with the other mixtures. In general, the adjustment that was noted to give the most economical and constant operation for a particular mixture at the highest full load testing speed with a maximum brake horsepower about the same as or higher than the maximum for gasoline, was used for all full load and fractional load tests in that fuel. The road tests for each fuel were carried out with the same adjustments as in the bench test.

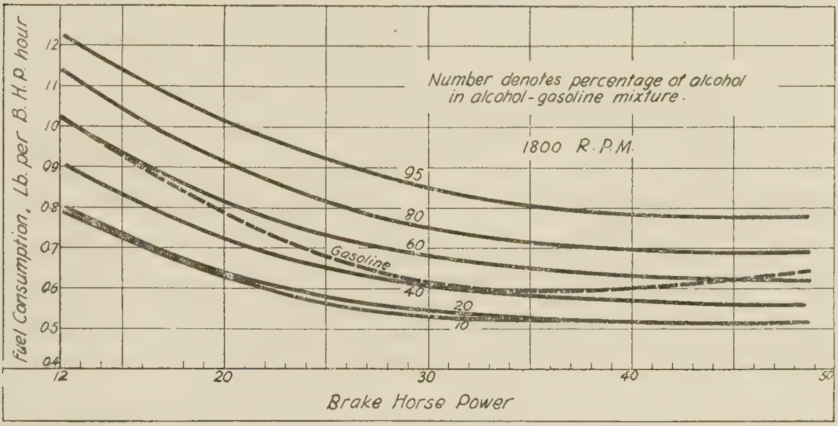

Chart 2.—Performance curves at 1800 R.P.M. (Number indicates percentage of alcohol in the mixture by volume.)

RESULTS AND DISCUSSION

Group I—Block tests

Results of the block test using compression ratio 6.3:1 was published in series V.[5]

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[5] A. L. TEODORO. 1936. Alcohol and alcohol-gasoline blends as fuels for automotive engines: V. Studies on the performance of an eight-cylinder engine using gasoline, dehydrated alcohol, and dehydrated alcohol-gasoline mixtures. The Philippine Agriculturist 24: 839–853.

Tables 1 and 2 and charts 1 to 9 inclusive show the total and the specific fuel consumption when compression 7.5:1 was used.

Gasoline. The engine failed to carry more than one-half of the rated load when it was run with gasoline. Starting was easy from cold with high compression heads but operation was shaky at idling and at high speeds. A one-half load detonation was much in evidence when accelerating. The data obtained on this fuel was not used for comparison.

Mixture A. Constant operation could not be maintained for over 10 seconds at full throttle with the use of mixture A, on account of detonation. The power developed by accelerating to full throttle was however, very much higher than the maximum that could be obtained with gasoline using compression ratio 6.3:1. A three-fourths load detonation was evident but the engine could maintain the required load at each speed for about 30 minutes. Continuous running of the engine for over half an hour at each speed resulted in a decrease in power and an increase in fuel consumption. Operation at half load and at one-fourth load was economical and steady without any detonation. Detonation was incipient between one-half and three-fourths loads at about 1400 R.P.M. Retarding the accele-

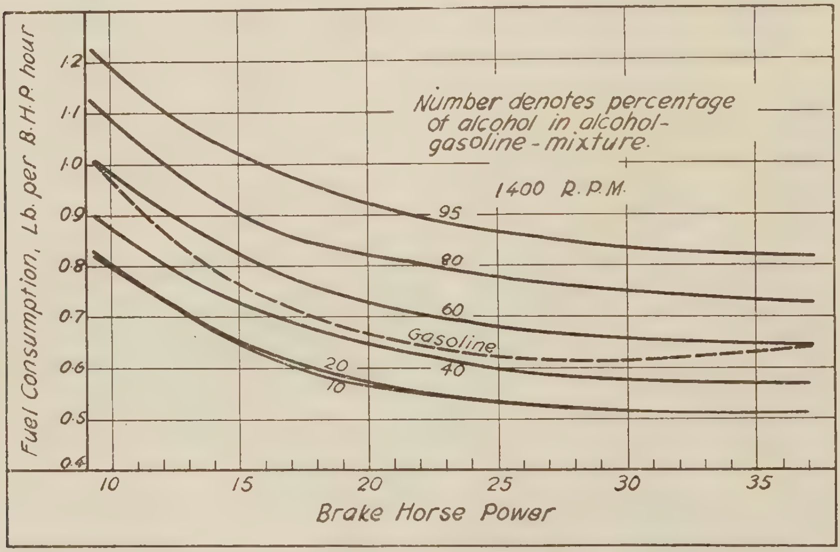

Chart 3.—Performance curves at 1400 R.P.M. (Number indicates percentage of alcohol in the mixture by volume.)

ration at full throttle minimized the detonation but caused an increase in fuel consumption and a decrease in load varying from 5 to 15 per cent within 10 seconds.

Mixture B. Engine performance at full load was steady for each speed when mixture B was used. Although detonation was evident during the full-load test, no effect on the fuel consumption and on power was noted until after more than half an hour of testing in each speed. At three-fourths load detonation was incipient at about 700 R.P.M. The power developed at 2200 R.P.M. on full throttle was higher by more than 10 per cent than the maximum for gasoline using compression ratio 6.3:1. The engine operated very well at all other speeds and loads.

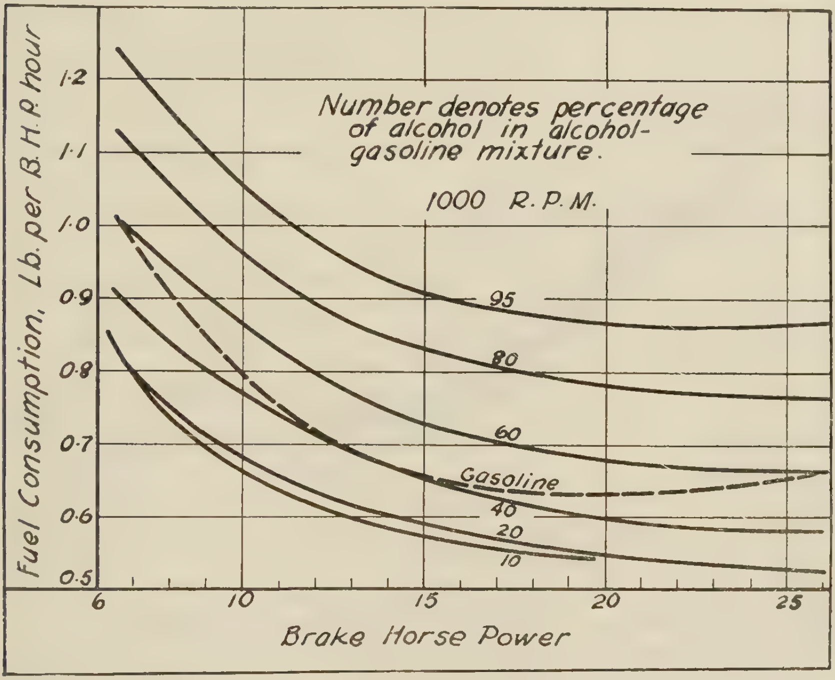

Chart 4.—Performance curves at 1000 R.P.M. (Number indicates percentage of alcohol in the mixture by volume.)

Mixtures C, D, E, and F. No sign of detonation was noted in any of the tests using mixtures C, D, E, and F. The operation was steady, greater power was developed, and the fuel consumption was lower than the corresponding consumption when the same fuels with compression ratio 6.3:1 were used. The specific fuel consumption with mixture C was lower at all loads than the corresponding consumption of gasoline. At full throttle the consumption with mixture B was slightly less than the gasoline consumption at the same load. At fractional loads, however, the consumption with mixture D was slightly higher than with gasoline. Mixtures E and F showed greater consumption than gasoline at all loads and speeds.

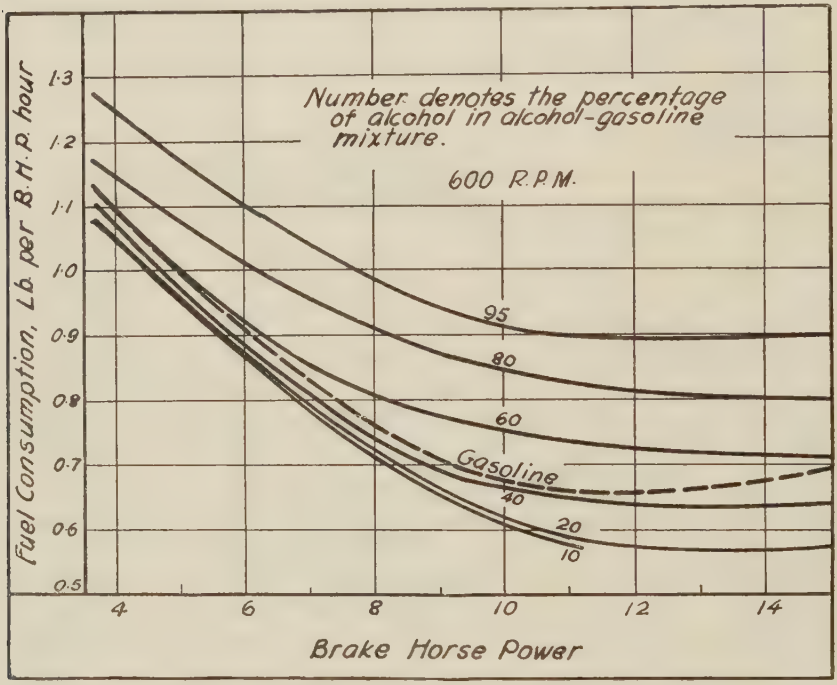

Chart 5.—Performance curves at 600 R.P.M. (Number indicates percentage of alcohol in the mixture by volume.)

A comparison of the maximum power developed at full throttle with gasoline and with mixture C is as follows:

	B.h.p. developed	
R.P.M.	*Compression ratio 6.3 : 1 Gasoline*	*Compression ratio 7.5 : 1 Mixture C*
2200	56.0	66.90
1800	46.0	54.00
1400	35.0	42.00
1000	24.0	29.15
600	14.0	16.00

The maximum power developed at the same load and speeds with mixtures D, E, and F differed from those of mixture C by ± 3 per cent. The tests at full load when mixtures C, D, E, and F were used were carried on by closing the throttle a little in order to develop maximum power that was about the same as those obtained with gasoline using compression ratio 6.3:1. With wide open throttle and smaller carburetor jets, only the maximum power at 2200 and 1800 R.P.M. could be made the same as the maximum for gasoline. The operation at lower speeds with this adjustment was unsteady and the power developed was smaller than those that could be obtained using gasoline.

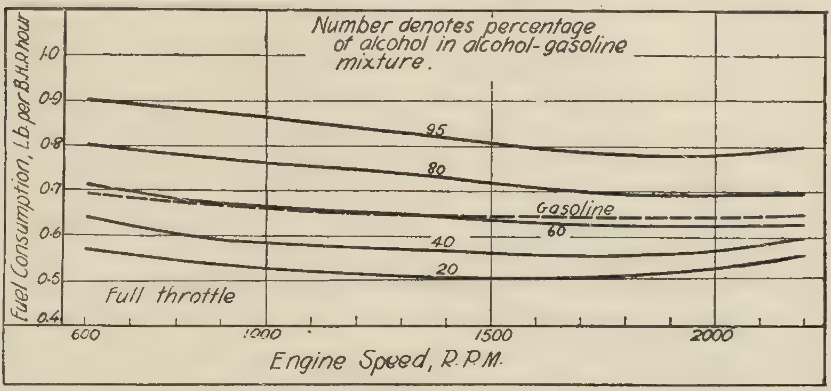

Chart 6.—Fuel economy curves at full load. (Number indicates percentage of alcohol in the mixture by volume.)

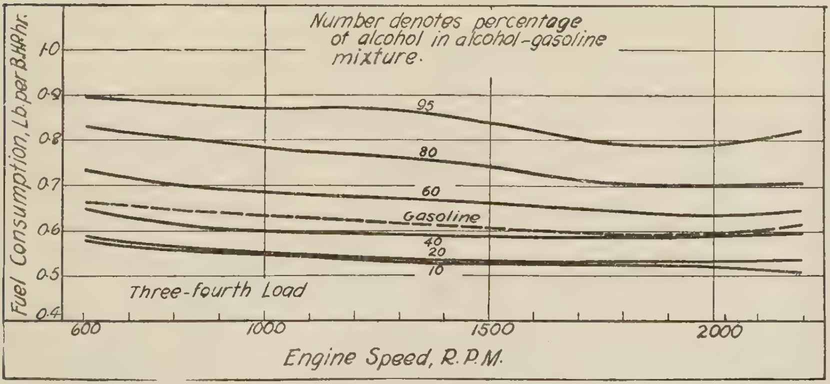

Chart 7.—Fuel economy curves at three-fourths load. (Number indicates percentage of alcohol in the mixture by volume.)

Group II—Road tests

The following were observed during the road tests when high-compression heads were used:

Gasoline. Fair result was obtained with gasoline under the condition in which the tests were carried out. Detonation was very much in evidence when the car was accelerated, when it rounded curves, and when it climbed hills. Normal running was made on level road when using moderate speeds. The mileage was higher than those with low compression heads. Great loss of power and

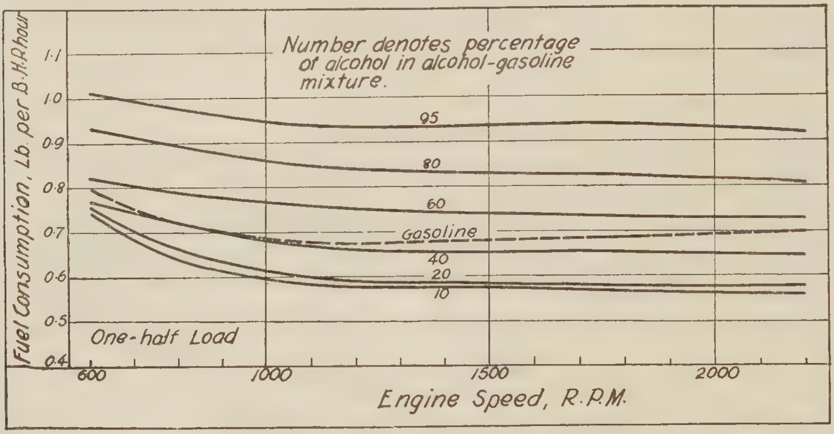

Chart 8.—Fuel economy curves at one-half load. (Number indicates percentage of alcohol in the mixture by volume.)

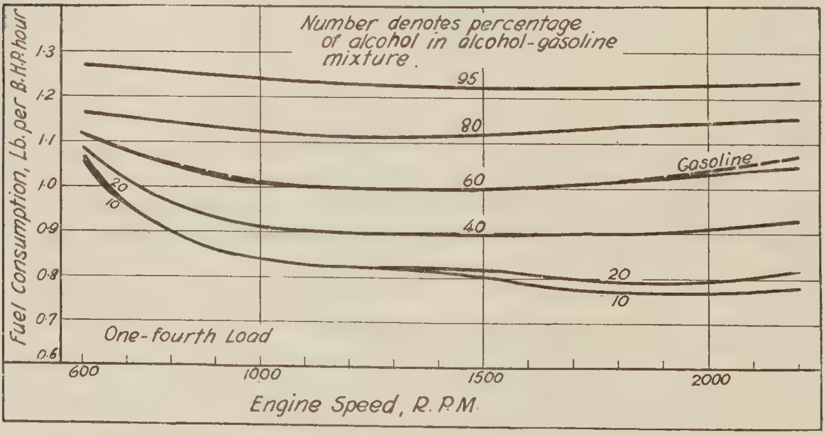

Chart 9.—Fuel economy curves at one-fourth load. (Number indicates percentage of alcohol in the mixture by volume.)

unsteadiness in operation were noticed when the car speed was made more than 35 miles an hour.

Mixtures. Practically no detonation was heard with any of the mixtures. The engine started easily from cold and the operation was steady under all conditions of test. There was no decrease in power even in climbing hills.

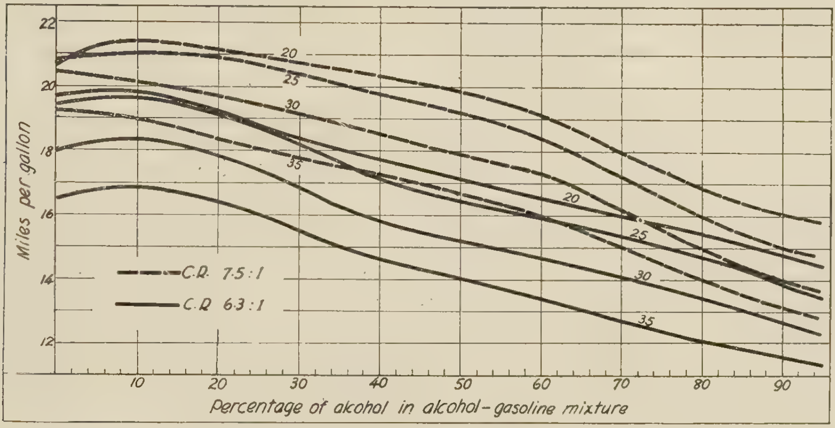

Chart 10.—Mileage at different speeds. (Number indicates speed in miles per hour.)

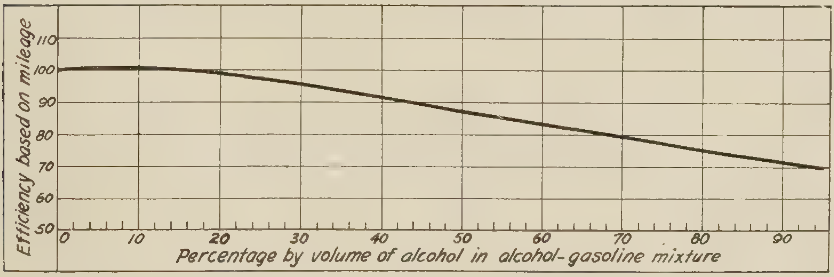

Chart 11.—Efficiency based on average mileage for all speeds using high compression heads. Note that the average mileage obtained with gasoline was used as 100 per cent. This average was about 10 per cent higher than the average obtained with gasoline at low compression heads. The engine could not develop with gasoline more than one-half of the rated load when high compression heads were used.

The curves in chart 10 definitely show the following:

1. That the mileage obtained with the use of mixture A was the highest in all of the tests.

2. That as the percentage of alcohol in the alcohol-gasoline mixture was increased the mileage decreased. As shown in chart 11, the average decrease in efficiency per every 10 per cent of alcohol

added in the mixture beginning from mixture A, was about 3.5 per cent. (Efficiency was based on mileage with gasoline when using compression ratio 7.5:1).

3. That at compression ratio 7.5:1 the mileage obtained with mixtures containing 20 to 40 per cent alcohol was higher than those with gasoline at compression ratio 6.3:1. The mileage obtained with mixtures containing 40 to 60 per cent alcohol was about the same as the mileage with gasoline.

4. That in general, the lower the speed the greater was the mileage.

SUMMARY

Gasoline (ordinary)

1. The Ford V-8 engine when tested on the bench at compression ratio 7.5:1 could not develop more than one-half of the maximum power that the engine could develop at compression ratio 6.3:1. With four passengers as car load and at speed of 20 to 35 miles per hour, higher mileage could be obtained with the use of high compression heads than with low compression heads. Detonation was very much in evidence when accelerating, when rounding curves, and when climbing hills. Unsteadiness in operation and loss of power were observed at speeds greater than 35 miles per hour.

Mixtures

2. Detonation was so heavy at full load using mixture A that it was not possible to obtain constant operation for over 10 seconds at any of the desired speeds. At three-fourths load using mixture A and at full load using mixture B, detonation was evident though the engine could maintain constant load at the desired speed for about thirty minutes. No detonation was heard in any other tests.

3. The specific fuel consumption and the mileage obtained with mixtures containing 40 to 60 per cent alcohol when using high compression heads were nearly the same as those obtained with gasoline when using lower compression heads. The mileage obtained with the mixtures containing 10 to 40 per cent alcohol was greater than those with gasoline. The mileage gradually decreased as the percentage of alcohol in the mixture was increased from 10 to 40 per cent. The decrease in mileage was from about 1.8 to 4.5 per cent per every 10 percent of alcohol added in the mixture with fuels containing 40 to 95 per cent alcohol.

4. The maximum power developed at the highest speed on full load with high compression ratio when using the mixtures was more than 10 per cent greater than the maximum power that could be developed at the same load with gasoline when using compression ratio 6.3:1.

TABLE 1

Total amount of fuel used

LOAD	ENGINE SPEED IN R. P. M.	ENGINE POWER IN B. H. P.	TOTAL FUEL CONSUMPTION IN POUNDS PER HOUR						
			Gasoline C. R. 6.3:1	Alcohol-gasoline mixtures. Number indicates per cent of alcohol in mixture by volume. C. R. 7.5:1					
				10 Mixture A	20 Mixture B	40 Mixture C	60 Mixture D	80 Mixture E	95 Mixture F
Full throttle	2200	60.50	37.80 [a]	[c]	34.30 [d]	36.00	38.20	42.05	48.35
	1800	48.80	30.62 [b]		25.22 [d]	27.30	30.60	33.71	38.07
	1400	37.33	24.10		19.18 [d]	21.20	24.00	27.20	30.60
	1000	26.25	17.37		13.96 [d]	15.30	17.40	20.08	22.82
	600	15.00	10.39		8.56 [d]	9.60	10.71	12.00	14.15
Three-fourths load	2200	45.00	27.62	22.72 [d]	23.85	26.82	29.05	31.95	37.20
	1800	36.75	21.72	19.16 [d]	19.19	19.23	23.52	26.10	29.18
	1400	28.00	17.14	14.62 [d]	14.83	16.50	18.76	21.30	24.05
	1000	19.70	12.43	10.68 [d]	10.80	11.80	13.42	15.36	17.13
	600	11.24	7.42	6.50 [d]	6.60 [e]	7.28	8.23	9.31	10.08
One-half load	2200	30.07	21.00	16.80	17.40	19.36	21.80	24.20	27.60
	1800	24.38	16.80	13.85	14.16	15.90	17.92	20.10	22.80
	1400	18.67	12.70	10.80	10.98	12.27	13.87	15.49	17.50
	1000	13.12	9.00	7.81	8.07	9.00	10.00	11.28	12.40
	600	7.50	6.00	5.66	5.70	5.80	6.20	6.99	7.60
One-fourth load	2200	15.03	16.12	11.82	12.33	13.92	15.76	17.36	18.60
	1800	12.23	12.50	9.60	9.73	11.00	12.43	13.95	15.00
	1400	9.34	9.38	7.63	7.72	8.36	9.40	10.40	11.38
	1000	6.58	6.68	5.50	5.52	6.00	6.66	7.39	8.20
	600	3.75	4.20	4.00	4.06	4.10	4.20	4.38	4.76

[a] Consumption at 58.72 B.H.P. Highest power that could be developed.

[b] Consumption at 47.61 B.H.P. Highest power that could be developed.

[c] Detonation was very evident. Engine could not maintain required load for 10 seconds. Operation was poorer with advanced spark. With retarded spark, detonation was minimized but load was decreased.

[d] Detonation was evident but engine could maintain required load for over twenty minutes.

[e] Detonation was heard faintly.

Note: Load was on "full throttle" only for gasoline using compression ratio 6.3:1. Engine was throttled to develop the same power as was developed with gasoline when mixtures were used with compression ratio 7.5:1. Greater maximum power could be developed at different speeds and on full throttle with the use of mixtures at compression ratio 7.5:1.

TABLE 2

Specific fuel consumption

LOAD	ENGINE SPEED IN R. P. M.	ENGINE POWER IN B. H. P.	SPECIFIC FUEL CONSUMPTION IN POUNDS PER BRAKE HORSEPOWER HOUR						
			Gasoline C. R. 6.3:1	Alcohol-gasoline mixtures. Number indicates per cent of alcohol in mixture by volume. C. R. 7.5:1					
				10 Mixture A	20 Mixture B	40 Mixture C	60 Mixture D	80 Mixture E	95 Mixture F
Full throttle	2200	60.50	0.644 [a]	[c]	0.567 [d]	0.595	0.630	0.695	0.799
	1800	48.80	0.643 [b]		0.517 [d]	0.559	0.621	0.691	0.780
	1400	37.33	0.645		0.514 [d]	0.568	0.643	0.729	0.820
	1000	26.25	0.662		0.532 [d]	0.583	0.663	0.764	0.870
	600	15.00	0.693		0.577 [d]	0.640	0.714	0.800	0.900
Three-fourths load	2200	45.00	0.614	0.505 [d]	0.530	0.596	0.645	0.710	0.827
	1800	36.75	0.591	0.522 [d]	0.523	0.588	0.640	0.710	0.794
	1400	28.00	0.612	0.522 [d]	0.530	0.589	0.670	0.761	0.857
	1000	19.70	0.631	0.542 [d]	0.548	0.599	0.681	0.780	0.870
	600	11.24	0.660	0.578 [d]	0.587 [e]	0.648	0.732	0.828	0.897
One-half load	2200	30.07	0.699	0.559	0.579	0.644	0.725	0.805	0.918
	1800	24.38	0.690	0.568	0.581	0.652	0.735	0.825	0.935
	1400	18.67	0.680	0.579	0.588	0.657	0.743	0.830	0.937
	1000	13.12	0.686	0.595	0.615	0.686	0.762	0.860	0.945
	600	7.50	0.800	0.755	0.760	0.773	0.826	0.932	1.013
One-fourth load	2200	15.03	1.073	0.786	0.820	0.926	1.048	1.155	1.237
	1800	12.23	1.022	0.785	0.795	0.900	1.016	1.140	1.226
	1400	9.34	1.004	0.817	0.827	0.895	1.006	1.114	1.220
	1000	6.58	1.015	0.836	0.833	0.912	1.013	1.124	1.246
	600	3.75	1.120	1.066	1.073	1.094	1.120	1.168	1.271

[a] Consumption at 58.72 B.H.P. Highest power that could be developed.

[b] Consumption at 47.61 B.H.P. Highest power that could be developed.

[c] Detonation was very evident. Engine could not maintain required load for 10 seconds. Operation was poorer with advanced spark. With retarded spark, detonation was minimized but load was decreased.

[d] Detonation was evident but engine could maintain required load for over twenty minutes.

[e] Detonation was heard faintly.

Note: Load was on "full throttle" only for gasoline using compression ratio 6.3:1. Engine was throttled to develop the same power as was developed with gasoline when mixtures were used with compression ratio 7.5:1. Greater maximum power could be developed at different speeds and on full throttle with the use of mixtures at compression ratio 7.5:1.

TABLE 3

Brake thermal efficiency

LOAD	ENGINE SPEED IN R. P. M.	ENGINE POWER IN B. H. P.	BRAKE THERMAL EFFICIENCY, PER CENT						
			Gasoline C. R. 6.3:1	Alcohol-gasoline mixtures. Number indicates per cent of alcohol in mixture by volume. C. R. 7.5:1					
				10 Mixture A	20 Mixture B	40 Mixture C	60 Mixture D	80 Mixture E	95 Mixture F
Full throttle	2200	60.50	19.61[a]	[c]	24.29[d]	25.44	26.75	27.29	27.14
	1800	48.80	19.64[b]		26.63[d]	27.08	27.14	27.45	27.80
	1400	37.33	19.58		26.79[d]	26.65	26.21	26.02	26.45
	1000	26.25	19.08		25.88[d]	25.96	25.42	24.83	24.93
	600	15.00	18.23		23.87[d]	23.65	23.60	23.71	24.10
Three-fourths load	2200	45.00	20.57	26.09[d]	25.98	25.40	26.13	26.71	26.22
	1800	36.75	21.37	25.24[d]	26.33	25.74	26.33	26.71	27.31
	1400	28.00	20.64	25.24[d]	25.98	25.70	25.15	24.92	25.31
	1000	19.70	20.02	24.31[d]	25.13	25.27	24.75	24.32	24.93
	600	11.24	19.14	22.80[d]	23.46[e]	23.36	23.02	22.91	24.18
One-half load	2200	30.07	18.07	23.57	23.78	23.50	23.25	23.56	23.62
	1800	24.38	18.30	23.20	23.70	23.22	22.93	22.99	23.19
	1400	18.67	18.57	22.76	23.42	23.04	22.68	22.85	23.15
	1000	13.12	18.41	22.14	22.39	22.07	22.12	22.05	22.95
	600	7.50	15.79	17.45	18.12	19.58	20.40	20.35	21.41
One-fourth load	2200	15.03	11.77	16.76	16.79	16.35	16.08	16.42	17.53
	1800	12.23	12.36	16.78	17.32	16.82	16.59	16.64	17.69
	1400	9.34	12.58	16.13	16.65	16.91	16.75	17.03	17.78
	1000	6.58	12.44	15.76	16.41	16.60	16.64	16.87	17.41
	600	3.75	11.28	12.36	12.83	13.84	15.05	16.24	17.06

[a] Consumption at 58.72 B.H.P. Highest power that could be developed.

[b] Consumption at 47.61 B.H.P. Highest power that could be developed.

[c] Detonation was very evident. Engine could not maintain required load for 10 seconds. Operation was poorer with advanced spark. With retarded spark, detonation was minimized but load was decreased.

[d] Detonation was evident but engine could maintain required load for over twenty minutes.

[e] Detonation was heard faintly.

Note: Load was on "full throttle" only for gasoline using compression ratio 6.3:1. Engine was throttled to develop the same power as was developed with gasoline when mixtures were used with compression ratio 7.5:1. Greater maximum power could be developed at different speeds and on full throttle with the use of mixtures at compression ratio 7.5:1.

TABLE 4

Results of mileage tests on the road

FUEL [a]	COMPRESSION RATIO	SPEEDOMETER SPEED PER HOUR							
		20 MILES 32 KILOMETERS		25 MILES 40 KILOMETERS		30 MILES 48 KILOMETERS		35 MILES 56 KILOMETERS	
		mi./gallon	*km./liter*	*mi./gallon*	*km./liter*	*mi./gallon*	*km./liter*	*mi./gallon*	*km./liter*
Gasoline	6.3 : 1	19.64	8.35	19.45	8.27	17.96	7.64	16.46	7.00
	7.5 : 1 [b]	20.57	8.74	20.81	8.85	20.43	8.70	19.26	8.19
10 Mixture A	6.3 : 1	19.82	8.43	19.62	8.35	18.32	7.79	16.84	7.16
	7.5 : 1 [c]	21.43	9.12	21.00	8.93	20.12	8.56	18.95	8.06
20 Mixture B	6.3 : 1	19.20	8.16	19.13	8.14	17.83	7.58	16.40	6.98
	7.5 : 1	21.12	8.98	20.87	8.88	19.69	8.38	18.33	7.80
40 Mixture C	6.3 : 1	17.70	7.53	17.02	7.24	15.78	6.71	14.60	6.21
	7.5 : 1	20.38	8.67	19.75	8.40	18.51	7.88	17.27	7.35
60 Mixture D	6.3 : 1	16.52	7.03	15.90	6.77	14.66	6.24	13.36	5.69
	7.5 : 1	19.13	8.14	18.45	7.85	17.33	7.38	16.02	6.82
80 Mixture E	6.3 : 1	15.34	6.53	14.72	6.26	13.42	5.71	12.11	5.15
	7.5 : 1	16.84	7.16	15.96	6.79	14.91	6.34	13.98	5.95
95 Mixture F	6.3 : 1	14.47	6.16	13.48	5.74	12.30	5.23	11.36	4.83
	7.5 : 1	15.78	6.72	14.72	6.27	13.60	5.79	12.80	5.44

[a] Number indicates per cent of alcohol in the alcohol-gasoline mixtures by volume.
[b] Fuel detonated heavily when going up-hill and on accelerating.
[c] Engine detonated when going up-hill and on turning corners.

FARM CREDIT IN APARRI, CAGAYAN [1]

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One of the greatest needs of Philippine agriculture is getting the money to the man needing it for farming. The machinery for distributing agricultural capital in the Philippines is still woefully inadequate. In fact, there is virtually no such machinery for the rank and file of the farmers and prospective farmers.

The need for agricultural credit facilities has long been felt by the Philippine government. In 1908, an agricultural bank was established by law, but perhaps because of the inadequacy of experience in the management of such an institution, the service of this bank did not accomplish any fruitful results. Consequently, its interests were taken over by the Philippine National Bank, when this new banking institution was established in 1916. During that year (1916), the government also encouraged the development of agricultural co-operative credit associations by the passage of Act No. 2508, otherwise known as the Rural Credit Law, by the Philippine Legislature. There were up to January 1, 1934, five hundred and seventy-one of these societies in operation in 43 provinces throughout the archipelago. The activities of these co-operative credit societies, however, did not improve the credit situation in our agricultural communities. On November 16, 1931, the Philippine Legislature passed two laws encouraging further the development of agricultural credit facilities. One of these acts, Act No. 3895, authorized the establishment of rural cooperative credit associations under the direction and control of the Philippine National Bank. Only four of such associations were in operation up to February 1, 1935. The other act, Act No. 3896, authorized the establishment of rural banks to aid the farmers. Six of such banks have been established up to February 1, 1935, two of which are in the province of Cavite, one in Canlubang, Laguna, two in the province of Bataan, and one in Naujan, Mindoro.

In 1933, the Philippine National Bank started to open up agencies in the various provinces. These agencies are allowed to lend money to small farmers amounting to from ₱5 to ₱600, depending on the

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[1] Experiment Station contribution No. 1140. Received for publication July 24, 1936.

market value of the estimated production of their farms and the assessed value of the property offered for additional security for such loans. Each provincial agency is under the administration of the provincial treasurer, who is assisted in some provinces by the bank's agency inspector. The agencies have sub-agencies in the municipalities of each province. These sub-agencies are under the administration of the municipal treasurers. By September 30, 1935, the bank reported that there were 40 agencies and 826 sub-agencies in operation throughout the Philippines. They granted loans amounting to ₱1,100,000, to 12,000 farmers, an average of less than ₱100 per borrower. But we have about two million farms, which are, of course, being worked by a much larger number of people. The accomplishment, however, is very encouraging, considering the fact that the agencies are still in the process of organization in many provinces.

The agencies have a long way to go, however, if they would attain a development such as that of agricultural credit systems elsewhere. Finland with a population of about four millions and a total land area of 149,641 square miles, for instance, had in 1928 over 1,400 agricultural co-operative banks with a capital of one billion Finnish marks (about ₱50,380,377)[2] and serving about one-third of the farmers of that country.

The work covered by this study was performed during the period from April 7 to 30, 1936, mostly in the town of Aparri, and partly in Tuguegarao, Cagayan.[3] It is a study of the sub-agency of the Philippine National Bank in Aparri, particularly of its activities in connection with loans to farmers of that town.

The purpose of this study was to get first-hand information about the service rendered by that sub-agency of the bank to the farmers in Aparri and to suggest improvements in this service if any room for them was discovered.

The survey method of investigation was used. Records of loans granted to farmers on crops by the sub-agency of the Philippine National Bank in Aparri were examined and studied. Then, representative borrowers, the municipal treasurer and his clerks who had to do with the inspection of farms offered for security for loans, as well as individuals who were non-borrowers, were interviewed and information about the lending activities of the sub-agency obtained from them. The provincial treasurer and the bank's agency inspector were also interviewed at Tuguegarao.

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[2] ₱1 is equivalent to 19.85 Finnish marks. See *World Almanac*, 1936, p. 640.

[3] Aparri, the largest town in Cagayan, had on July 1, 1935, an estimated population of 23,106. Tuguegarao, the second largest town in that province, had on the same date an estimated population of 22,425.

Amount of loans granted

The agency of the Philippine National Bank in Cagayan began granting crop loans to farmers in that province on September 1, 1935. Up to April 14, 1936, the total amount of such loans granted by this agency to 2,990 farmers was ₱116,378.66, an average of a little over ₱38.92 per borrower. The records of the provincial agency, however, did not indicate the distribution of this amount to the different borrowers by municipality. This was because each sub-agency keeps a record of its loans to farmers in the municipality. A study of the activities of the sub-agencies, therefore, had to be done at the primary sources of information, at the offices of the municipalities where the sub-agencies have been opened. Since time and expense did not permit the writer to study all of the sub-agencies in the province, it was decided that a study of the activities of the sub-agency in Aparri would furnish a general knowledge of the service now being rendered by these agencies of the Philippine National Bank.

The amount loaned out by the sub-agency in Aparri during the period from the beginning of its operation on October 18, 1935 up to March 31, 1936 was ₱14,250.00. This sum was granted to 408 borrowers, giving an average of ₱34.92 per borrower. Since there are between 8,000 and 10,000 farmers in Aparri, this sub-agency had served, therefore, not less than 5.1 per cent of the farmers in that town.

Distribution and size of loans granted by the sub-agency of the P. N. B. in Aparri

The loans granted by this sub-agency ranged from ₱10.00 to ₱50.00. Table 1 shows the frequency distribution of the loans in respect to amounts and also the geographical spread of said loans over the entire area of the municipality. The table indicates that the ₱14,250 loaned out was distributed as follows: 158 farmers, or 38.73 per cent, of the total number of borrowers, received ₱50-peso loans; 14, or 3.43 per cent, loans of ₱45 each; 22 or 5.39 per cent, loans of ₱40 each; 9, or 2.2 per cent, loans of ₱35 each; 63, or 15.44 percent, loans of ₱30 each; 33, or 8.09 per cent loans of ₱25 each; 60, or 14.71 per cent, loans of ₱20 each; 24, or 5.88 per cent, loans of ₱15 each; and 25, or 6.13 per cent, loans of ₱10 each.

The proportion of the various amounts of loans to the total was as follows: The fifty-peso loans, totaling ₱7,900, constituted 55.45 per cent of all the loans; the forty-five-peso loans, amounting to ₱360, were 2.53 per cent; and the ten-peso loans, ₱250, were 1.75 per cent; the twenty-five-peso loans, ₱825, were 5.79 per cent; the twenty-peso loans, ₱1,200, were 8.42 per cent; the fifteen-peso loans, ₱360, were 2.53 per cent; and the ten-peso loans, ₱250, were 1.7 per cent.

As to geographical distribution, the fifty-peso loans were the most widely scattered over the entire area of the municipality, there being 25 out of the 30 barrios of the town represented by the borrowers. The smaller loans were not as widely scattered as the fifty-peso loans.

The predominance and popularity of the fifty-peso loans seem to support the claim of the borrowers that the loans being extended to them by the sub-agency are not sufficient for the production needs on their farms. Even the maximum amount of ₱50 loaned out by the sub-agency is not sufficient to pay for the seeds and implements that they need. The borrowing farmers contended that with a much larger loan than what they were then getting they could use their credit to a much better advantage.

Relation of loan to value of property used as security

All the crop loans granted by the sub-agency of the Philippine National Bank in Aparri were secured by land. It appears that these loans were granted under the authority of section 11 (C) of Act No. 2847 entitled: "An act to amend in certain particulars Act Numbered Twenty-Six Hundred and Twelve, entitled 'An act creating the Philippine National Bank' ", which reads as follows:

> Section 11. Said National Bank is hereby authorized . . . (C) To make loans to agriculturists in installments, on standing crops of the natural products of the Philippine Islands, such as rice, hemp, copra, sugar, tobacco, corn, maguey, etc., not in excess of three-fifths of the estimated value of such crops: Provided, however, That before granting such loans, the National Bank may require additional security in the nature of mortgages, including those upon livestock, machinery, and agricultural implements, or personal bonds with sufficient surety or sureties, satisfactory to the bank."

The relationship between the loans and the value of the farms used as security is shown in table 2. The data contained in this table are from applications of representative borrowers which have not as yet been forwarded to the provincial agency at Tuguegarao at the time of the survey. This table indicates that the total amount of ₱1,845 borrowed by 53 farmers was secured by 354.137 hectares of land with an assessed value of ₱35,288.15. In other words, the total amount loaned out to these farmers represented only 5.22 per cent of the total assessed value of the farms which they used as security for their loans. Considered individually, none of these 53 farmers, disregarding number 7 (in table 2) whose farm has been encumbered up to 83.33 per cent of its assessed value, has encumbered his land beyond one-third of its assessed value. The majority of them borrowed amounts representing less than 10 per cent of the assessed values of their farms. Yet, in the majority of cases, the assessed values of these farms were far below their actual market value at the time of the survey.

Asked why the farmers are not granted more liberal loans, the officials of the provincial agency of the bank at Tuguegarao explained that they will be given larger loans than what they are getting now eventually. The experience of the bank, through its branch in Aparri several years ago, has taught it to be cautious. At present, the agency's policy is to be strict in its business dealings with the borrowers but when it finds out that the debtors do their share of the bargain, it will gradually extend more liberal loans to them. There is danger that, if the farmers are granted loans up to the maximum amount allowed by law, they might look upon the service of the agency as a charitable help extended to them by the government. If they took this attitude, the collection of debts would be very difficult and there is danger of failure for the agency. When the agency, through a few years of experience, has discovered that the farmers meet their obligations promptly and use their credit wisely, then, it will be time for the farmers to deserve loans as large as the law allows them to have.

Procedure in obtaining loan

A farmer who desires to obtain a loan from the sub-agency goes to the municipal treasurer's office and fills in an application blank already prepared by the Philippine National Bank for this purpose. This application states the date of its filing, the name, exact residence, and civil status of the applicant, the amount of money desired, the duration and manner of payment of the loan. In addition, the application describes the location, character, and assessed value of the property offered as security for the loan. If the property is a piece of land, a statement showing evidence that the tax on the property has been paid is also required. If the applicant so desires, he may also give the description and value of other properties which he possesses. The filled-in application, signed by the applicant, is filed with the municipal treasurer. Upon its receipt, the treasurer orders his representative to inspect the property offered by the applicant as security for the proposed loan.

The inspector goes to the place where the property is located together with the applicant. He finds out the productivity of the property from the farmer. If he is convinced of the authenticity of the farmer's figures, he estimates the total market value of the production of the land by multiplying this total production by 75 per cent of the actual market value of the product. The resulting amount is supposed to be the gross income of the farmer from this property. After 20 per cent, the usual share of labor in harvesting the crop (the borrowers of the sub-agency are rice farmers), has been subtracted from this, the residue, is known as the *living margin of mortgage* of the farmer. This residual amount determines how much he can pay on a mortgage loan on his land. To illustrate: Take borrower No. 1 in table 2. Let us suppose that this farmer produces 30 cavans of palay from each hectare of his 16-hectare farm, excluding from this estimate what he and his family use from the land's production. The total production of the land, therefore, will be 480 cavans. Let us suppose further that the actual price of palay in the market is ₱2 per cavan. Then, the total market value of the production of the farm is ₱960. But the inspector, for the protection of the bank, considers only 75 per cent of this, or ₱720. Subtracting from this amount 20 per cent, will leave ₱576, the maximum amount which the farmer is able to pay on a loan. This is his living margin of mortgage. But he applied for only ₱50, because that is the maximum amount which the sub-agency is authorized to loan.

The inspector's report on the eligibility of the property offered for security being satisfactory, the municipal treasurer signs the endorsement on the application, recommending its approval, to the provincial treasurer. The applicant is summoned and notified of this action, then, he is requested to sign a promissory note for the amount of the approved loan. He receives the amount, minus the interest and 2 centavos, which is the cost of documentary stamp placed on the application. The borrower gets the loan directly from the municipal treasurer, without waiting for the approval of the provincial treasurer, because for loans not exceeding ₱50 each, the municipal treasurer is authorized to use his discretion.

The method adopted by the sub-agency of the Philippine National Bank in Aparri to determine the ability of the farmer to repay his loan seems to bring about the same result as the standard method used in the United States and elsewhere. This standard method finds out whether the farmer is producing an income from his farm which will enable him to:

1. Pay interest on his capital at current rate;
2. Pay market rent on his land;
3. Pay wages to himself; and
4. Have a balance left over, after taking care of the above items, with which to pay amortization on his loan. This balance is the living margin of mortgage of the farmer. Applied to the average Filipino farmer, this method will be reduced to the sub-agency's method. The average Filipino farmer invests very little or no capital in agricultural implements, tools, machinery, and buildings. Consequently, the interest on the capital, if any, invested on the farm is negligible. The omission of interest on capital from the estimate of his income from the land, therefore, will not matter much. The size of the holding of the average Filipino farmer is very small, about 2.3 hectares. The market rent on such small holding is not much. So that, the use of only 75 per cent of the actual market value of the product to determine the market value of the production of the land will more than offset the omission of this item in estimating the living margin of mortgage of the Filipino farmer. The Filipino farmer constantly draws from the income of his land for his daily needs and those of his family, but no record of such withdrawals is kept. This is a justification for the sub-agency's omission of his wages in estimating the living margin of mortgage of his land. Under these conditions, therefore, the most practical way to find out the living margin of mortgage of the average Filipino farmer is simply to estimate his gross income and then substract from this amount 20 per cent, the usual sum spent for labor in harvesting his crop. The residual sum will be the living margin of mortgage of the farmer.

Use of credit by the borrowers

The applications of the borrowers of the sub-agency of the Philippine National Bank in Aparri reveal that the money was loaned to them for three purposes, as follows:

1. To pay land tax and cadastral fees;
2. To purchase seeds and work animals; and
3. For improving, plowing, and planting land.

It was not possible to examine all the applications of the 408 borrowers of the sub-agency, bceause 340 of them had already been forwarded to the provincial agency at the time of this survey. Information from the office of the municipal treasurer, as well as from non-borrowers, reveals that the majority of those who borrowed money during the month of October, 1935, used a part of their credit for paying their land taxes and cadastral fees. The amount due from each farmer who borrowed from the sub-agency for taxes and cadastral fees was deducted from the loan granted to him. As to how the borrowers used the rest of the money, the writer was not able to ascertain. However, a survey made from 20 borrowers picked at random reveals that these farmers used their credit for the following purposes:

Purposes	*Number of farmers using*
To pay for old debts, partly	5
Partly to purchase household supplies	12
Defray expenses of children in high school	8
Total	25

Five of those who testified that they used their credit for the purchase of supplies also declared that they had used part of it for paying their old debts. It can be seen then why the total is 25 instead of 20. If the testimonies of the twenty borrowers are representative of the way the rest of the borrowers spent the borrowed funds, then, there is a tendency that the bulk of the money loaned to them was used for purely consumptive purposes.

A study of the 68 applications which were still at the office of the municipal treasurer at the time of this survey reveals that these borrowers obtained their loans for the following purposes:

Purposes for which money is borrowed	*Number of farmers who borrowed under each purpose*
To pay land tax and cadastral fees	1
To purchase seeds and work animals	65
For improving, plowing, and planting land	2
Total	68

The 68 loans were obtained between January 7 and March 31, 1936. During this time, the harvesting of the rice crop was almost or just finished; the time for the payment of land tax and cadastral fees was not due for long, for it was only October; and the plowing and planting of the land was out of the question. These borrowers, therefore, must have been tempted to use their credit for purposes other than those they declared in their respective applications. If they did, the service of the sub-agency of the Philippine National Bank would be a burden, rather than a help, to these farmers. Their borrowing would only put them deeper into debt.

It appears that in order to minimize the temptation to use credit for purely consumptive purposes and to emphasize the importance of using borrowed funds for agricultural production, the sub-agency should grant loans to farmers only at certain periods of time during the year. If the farmers are to use their credit for crop production, loans should be granted to them during the period of preparation of the land and planting which, in Aparri, falls during the months of May, June, and July. If they intend to use their credit to tide them over while awaiting the sale of their crop, then the loans should be granted to them during the months of December, January, and February. No loans should be granted during the intervening periods.

Interest and duration of loans

The short-term agricultural loans granted by the sub-agency of the Philippine National Bank bear 10 per cent interest. Of this, 6 per cent goes to the bank, 3 per cent is retained by the provincial agency, and 1 per cent is the share of the sub-agency. The interest on the loan is deducted from the principal at the time the borrower obtains it.

The interest on loans is easily the lowest that the farmers of Appari can obtain on money borrowed. There are no banks in this largest town of the province of Cagayan; therefore, the only other sources of credit for the farmers are the usurers and the retail stores. The usurers usually collect one cavan of palay for every peso that they loan out. This means the payment of interest of as high as 200 per cent. The retail stores sell goods on time to the farmers, but such goods are for immediate consumption. The farmers usually repay the Chinese retailers in kind and in almost all cases they pay from 20 per cent to 50 per cent interest on goods bought by them on credit. Loans obtained from these sources, therefore, do not improve the lot of the farmers. On the contrary, they go deeper and deeper into debt if they persist in borrowing from them.

The short-term agricultural loans extended to the farmers of Aparri by the sub-agency of the Philippine National Bank are of one year duration. Loans may be renewed for another year, however, if in the judgment of the municipal and provincial treasurers, there is real justification, such as the failure of a crop, damages to stored crop through storm, etc., for such extension and provided that the borrower has paid back at least 20 per cent of the principal of the loan.

Cost and repayment of loans

The only expense incurred by borrowers of the sub-agency of the Philippine National Bank in Aparri is payment of 2 centavos for documentary stamp which must be attached to every approved application for loan. The services of the municipal treasurer and his assistants are rendered free. Since the municipal treasurer is usually too busy to attend to the work of the sub-agency, it is observed that the interests of both the farmers and the bank would be better served if a permanent employee of the bank handled the work of the sub-agency.

The principal of the loan is paid in full at the end of the term of the contract. Payment by the installment plan is not allowed on short-term agricultural loans.

Summary and conclusions

A study of the operation of the agency of the Philippine National Bank in Cagayan, particularly that of the sub-agency in Aparri, reveals the following facts and conclusions:

1. The provincial agency has loaned out ₱116,378.66 to 2,990 farmers during the period from September 1, 1935, when it began granting short-term agricultural loans, to April 14, 1936, when this survey was conducted. The loans ranged in amounts from ₱5.00 to ₱50.00. The distribution of these loans by municipality could not be ascertained.

2. The sub-agency in Aparri has loaned out ₱14,250.00 to 408 farmers in that town during the period from October 1, 1935, when this sub-agency started operating, to March 31, 1936. This gave an average of ₱34.92 per borrower. Considering that there are between 8,000 and 10,000 farmers in Aparri, this sub-agency has, therefore, served at least 5.1 per cent of the farmers in that town.

3. The ₱14,250.00 loaned out by the sub-agency was distributed as follows: ₱7,900, or 55.45 per cent of the total, was in ₱50 loans to 158 farmers; ₱630.00, or 4.41 per cent, in ₱45-loans to 14 farmers; ₱880.00, or 6.18 per cent, in ₱40-loans to 22 farmers; ₱315.00, or 2.21 per cent, in ₱35-loans to 9 farmers; ₱1,800.00, or 13.26 per cent, in ₱30-loans to 63 farmers; ₱825.00, or 5.79 per cent, in ₱25-loans to 33 farmers; ₱1,200.00, or 8.42 per cent, in ₱20-loans to 60 farmers;

₱360.00, or 2.53 per cent, in ₱15-loans to 24 farmers; and ₱250.00, or 1.75 per cent, in ₱10-loans to 25 farmers.

The fifty-peso loans were the most widely scattered over the entire area of the municipality, there being farmers from 25, out of the 30 barrios represented by the borrowers, who borrowed this sum. This seems to indicate that there was a desire on the part of the farmers for loans of larger amounts.

4. The ₱14,250.00 loaned out by the sub-agency was secured by farms having an aggregate area of 354.1370 hectares and an assessed value of ₱35,285.15, showing that the loans represented only 5.22 per cent of the assessed value of the property used as their security. This was very low, considering that the law allows the bank to loan up to 60 per cent of the market value of land.

The sub-agency is allowed to loan up to 60 per cent of the market value of the estimated production of the land used as security, or up to 25 per cent over and above the living margin of mortgage of the farmer. None of the 408 borrowers of the sub-agency, however, has been allowed this maximum, partly because of the fact that the sub-agency has been authorized to loan an arbitrary maximum of ₱50 and because the failure of the Philippine National Bank's branch in Aparri several years ago has taught it to be cautious.

The very low proportion of the loans to the value of the security, however, indicates a justification on the part of the farmers in Aparri for their clamor for loans of larger amounts from the sub-agency.

5. There was a tendency on the part of the borrowers to use their credit for consumptive purposes. It was observed that this was perhaps due to the granting of loans at a time when they are not badly needed for agricultural production. Loans are granted by the sub-agency at any time of the year. To encourage borrowers to use their credit for agricultural production and improvement, loans should be granted only at certain periods of the year, when the money is needed by the farmers for the preparation of their land for planting and aiding them while waiting for the sale of their crop. Loans intended to help the farmers in raising their crops should be granted during the months of May, June and July. Those intended to aid them while waiting for the sale of their harvested crop should be granted during the months of December, January, and February. No loans should be granted during the intervening periods in order to minimize the temptation on the part of the farmers to use their credit for purely consumptive purposes.

6. The loans granted by the sub-agency bear 10 per cent interest. Of this, 6 per cent goes to the bank, 3 per cent is retained by the provincial agency, and 1 per cent is the share of the sub-agency. This rate is easily the lowest that the farmers in Aparri are charged for money borrowed, since they pay as high as 200 per cent to individuals who lend them money and collect crop which very often is twice the value of the principal. They also pay as much as 20 per cent to 50 per cent interest on goods purchased on time from retail Chinese stores.

7. The loans are of one year duration and the only expense incurred by the borrower, outside of interest, is 2 centavos to pay for documentary stamp which must be attached to every approved application for a loan. The municipal treasurer and his assistants render service free of charge. However, since the municipal treasurer and his clerks are usually very busy, the interests of the borrowers could be better served, and the service of the sub-agency could be more effective, if the bank employs a permanent individual with a knowledge of banking to look after the activities of the sub-agency.

8. Provided the farmers meet their obligations promptly and use their credit for productive purposes, the service of the sub-agency of the Philippine National Bank gives promise to improve their economic condition.

TABLE 1

Showing the distribution of loans granted by the Philippine National Bank's Sub-agency to farmers in Aparri, Cagayan, October 18, 1935, to January 6, 1936, and January 7 to March 31, 1936

BARRIOS	AMOUNT OF LOANS AND NUMBER OF BORROWERS									TOTAL OF LOANS
	₱50	₱45	₱40	₱35	₱30	₱25	₱20	₱15	₱10	
Centro	14	—	4	—	—	—	1	—	—	₱ 880
Casical-lan	2	—	—	—	—	—	—	—	—	100
Cabaritan	1	—	—	—	—	—	—	—	—	50
Linao	6	—	—	—	—	2	1	—	—	370
Maura	5	1	—	—	2	2	—	—	—	405
Bisagú	4	—	—	—	—	—	—	—	—	200
Bulala	13	—	—	1	3	2	4	2	2	925
Tal-luñgan	11	—	2	—	7	1	5	6	3	1,085
Binalonan	2	—	—	—	—	—	—	—	—	100
Paruddun, N.	11	—	3	2	10	5	7	3	1	1,360
Plaza	6	—	—	—	2	4	—	1	1	505
Bermejo	3	—	—	—	—	—	—	—	—	150
Buquig	1	—	—	—	—	—	—	—	—	50
Cacaluan	1	—	—	—	—	—	—	—	—	50
Toran	8	11	4	1	13	4	19	8	6	2,140
Zinarag	9	—	2	—	1	—	4	—	1	650
Bacquiling	1	—	—	—	—	1	—	—	—	75
Cappi	4	—	—	—	—	—	—	1	1	235
Tubal	1	—	—	—	—	—	—	—	—	50
Paddaya	17	—	1	3	13	3	9	1	2	1,675
Wauang	1	1	—	—	—	1	—	—	—	120
Ammubuan	1	—	—	—	—	—	—	—	—	50
Buneg	1	—	—	—	—	—	—	—	—	50
Nabagon	1	—	—	—	—	1	1	—	—	95
Santelmo	4	—	—	—	—	—	—	—	—	200
Ducan	—	—	1	—	2	—	—	—	—	100
Dodan	—	—	—	—	—	—	1	—	—	20
Panifuan	—	—	—	—	1	—	—	—	—	30
Bañgag	—	—	—	—	—	1	—	—	—	25
Nanappatan	—	—	—	—	—	1	—	—	—	25
c/o Abad	1	—	—	—	—	—	—	—	—	50
Gonzaga	—	—	—	1	—	—	—	—	—	35
Number of loans Oct., 1935 to Jan. 6, 1936	129	13	17	8	54	28	52	22	17	340
In Pesos	6,450	585	680	280	1,620	700	1,040	330	170	₱11,855
Number of loans Jan. 7 to Mar. 31, 1936	29	1	5	1	9	5	8	2	8	68
In Pesos	1,450	45	200	35	270	125	160	30	80	2,395
Total number of loans	158	14	22	9	63	33	60	24	25	408
Grand total amount of loans, pesos ..	7,900	630	880	315	1,890	825	1,200	360	250	₱14,250

TABLE 2

Showing the relationship between loans and the assessed value of farms used as security

BORROWER NO.	AMOUNT BORROWED	AREA AND VALUE OF FARMS USED AS SECURITY		PROPORTION OF LOANS TO ASSESSED VALUE OF SECURITY
		Area	Assessed value	
	pesos	*hectares*	*pesos*	*per cent*
1	50.00	16.1399	1,890.00	2.65
2	50.00	7.2886	340.00	14.70
3	20.00	2.0000	80.00	25.00
4	50.00	1.4873	470.00	10.64
5	50.00	5.0000	390.00	12.80
6	20.00	2.3320	140.00	14.28
7	50.00	2.6898	60.00	83.33
8	50.00	18.2045	790.00	6.33
9	40.00	4.1210	240.00	16.66
10	50.00	4.0856	420.00	11.90
11	10.00	0.8192	70.00	14.28
12	25.00	7.0000	175.00	14.28
13	30.00	2.1313	240.00	12.50
14	50.00	2.2910	150.00	33.33
15	50.00	10.0000	1,560.00	3.20
16	20.00	0.3799	190.00	10.52
17	20.00	1.0345	60.00	33.33
18	30.00	9.1271	1,010.00	2.97
19	40.00	11.0495	480.00	8.33
20	10.00	10.0000	130.00	7.69
21	25.00	5.0000	1,100.00	2.27
22	10.00	0.3091	60.00	16.66
23	35.00	2.2160	140.00	25.00
24	25.00	5.1466	2,790.00	0.89
25	50.00	15.4729	1,624.65	3.07
26	30.00	2.4925	413.10	7.26
27	45.00	16.0040	1,600.00	2.81
28	30.00	2.2071	260.00	11.54
29	30.00	2.6806	110.00	27.27
30	50.00	16.0000	1,200.00	4.16
31	10.00	1.2203	140.00	7.14
32	50.00	7.7185	790.00	6.32
33	40.00	16.0000	206.00	19.37
34	50.00	20.6803	2.480.00	2.01
35	50.00	4.0000	2,120.00	2.35
36	10.00	2.5070	315.00	3.17
37	50.00	23.2440	1,740.00	2.87
38	50.00	6.3932	800.00	6.25
39	10.00	1.3447	50.00	20.00
40	15.00	1.8034	60.00	25.00
41	50.00	6.5776	2,330.00	2.14
42	20.00	1.9538	250.00	8.00
43	10.00	0.5305	80.00	12.50
44	15.00	2.7058	130.00	11.53
45	50.00	10.1331	190.00	27.36
46	50.00	8.0772	484.00	10.33
47	50.00	3.2914	150.00	33.33
48	30.00	4.2664	420.00	7.14
49	50.00	22.4324	2,020.00	2.47
50	50.00	10.0000	1,240.00	4.03
51	20.00	3.8360	230.00	8.69
52	50.00	9.1699	650.00	7.69
53	20.00	1.6015	230.00	8.69
Total	1,845.00	354.1370	₱35,288.15	5.22

Note: The names of the borrowers, for obvious reasons, are not mentioned, and, instead, numbers are assigned to each of them.

THE RELATIVE YIELDING POWER OF LOWER AND UPPER EARS FROM TWO-EARED CORN PLANTS[1]

MELECIO S. DURAN

WITH ONE TEXT FIGURE

In a corn field one may find plants with two ears on a stalk, single-eared plants and even barren stalks. In field selection of seeds no recommendation has been made on the preference of one-eared, lower or upper ear as a source. But according to breeding and selection practices it is important to know the relative yielding power of lower ears and upper ears of the two-eared corn plants. To study this question the present investigation was undertaken.

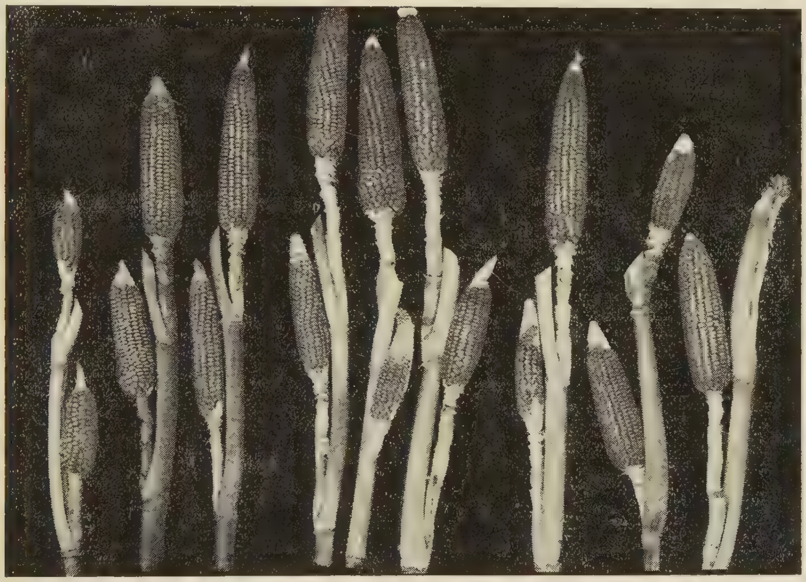

Fig. 1.—Two-eared corn stalks showing the upper and lower ears.

Many local, as well as foreign reports, have been made on the relation of ear characters to the yield of maize. But so far as the writer knows, no study in the Philippines has as yet been made on the comparative yielding power of lower ears and upper ears from two-eared plants. Of the numerous studies on corn breeding and selection reported from other countries, however, the following may be cited as having direct bearing on the present studies, so they are here reviewed briefly.

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[1] Thesis presented for graduation, 1935, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture, University of the Philippines, No. 505; Experiment Station contribution No. 1141. Prepared in the Department of Agronomy under the direction of Dr. J. M. Capinpin.

Grabner (1913)[2] found that a many-eared variety of corn was obtained by selecting from many-eared strains. He also found that the average weight of grains per ear in the many-eared plants was less than the average weight of grains per ear in the few-eared plants. He states further that some of the ears of the two-eared plants became sterile.

Reitz and Smith (1917)[3] found in their studies of Indian corn that the upper ear had a greater yielding power than the lower. They further reported that when planted no significant difference was found as to the frequency of one-eared or two-eared stalks from seeds from either ear.

STATEMENT OF THE PROBLEM AND OBJECTS

A corn plant with two ears, is the subject material of this study. According to taxonomic classification and in the order of ontogenical development, the lower is the first to appear, the upper appearing second. The present investigations were undertaken to find the answers to the following two questions: (*a*) Do plants arising from the seeds of the lower ear differ materially in stand from the plants grown from the seeds of the upper ear? (*b*) Which of the two ears is the better source of seed from the standpoint of yield when planted?

TIME AND PLACE OF THE STUDY

The work was conducted in the experiment station farms and plant breeding laboratory, department of Agronomy, College of Agriculture, University of the Philippines, from July, 1933 to December, 1934.

MATERIALS AND METHODS

Materials

Selection of materials. The Los Baños strain of the Native Yellow Flint planted in the experiment station in the dry season of 1933, was used as the source of seed materials. One hundred plants each with two developed ears borne on one stalk and one hundred plants each with one ear on a stalk were selected before harvest time. When the ears were matured, they were harvested attached to the stalks (fig. 1). The ears were dried for about three weeks before they were shelled.

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[2] GRABNER, E. 1913. A many-eared variety of corn obtained by selection in Hungary. Gaz. Lapok 51: 850. Abst. in International Inst. Agric. (Rome) Mo. Bull. Agric. Intelligence and Plant Diseases 5: 352–353.

[3] REITZ, H. L., AND L. H. SMITH. 1917. A statistical study of effect of certain selections in breeding Indian corn. Jour. Agric. Res. 21: 105–146.

Record of each ear. Before the ears were husked and shelled, fifty lower ears from the two-eared plants, fifty upper ears from the same two-eared plants and fifty ears from one-eared plants were individually labelled.

Each ear, both unhusked and husked, and the grains from both the two-eared plants and one-eared plants, were weighed on a Cenco balance. The length of the ears and the circumference at a point about one-third the length from the butt were also taken. As the corn was shelled, the grains of each ear were placed in a paper bag labelled to correspond with the label of the ear.

Preparation of the land

Before planting, the land was thoroughly prepared. It was plowed and harrowed twice in order to kill most of the weeds and to pulverize the soil thoroughly. After the last harrowing, furrows were made. For the dry-season culture, the land was prepared in the first two weeks of November; for the wet season culture, in the last week of May and the first week of June.

Planting

Dry-season culture. The ear-to-the-row method of planting was followed. The rows were set one meter apart and the seeds planted in hills 75 centimeters apart in the row. There were 100 hills in each row, and three seeds were planted to a hill, but after noting the number of seeds which germinated, the plants were later thinned to one plant to a hill. As there was no one field large enough available, two separate lots were used. One lot with an area of 6,750 square meters was planted on November 19, 1933, and the other with an area of 4,500 square meters on November 25, 1933.

Wet-season culture. The plan of planting in the wet season was the same as that in the dry season, except that in this culture there were only 50 hills in each row and the whole planting was in one lot. Seeds for this culture, except for the control, came from artificially self-pollinated plants grown in the previous season. The seeds were planted on June 7, 1934.

Self-pollination for seeds

Parent plants selected. Two plants in the lower- and upper-ear-row, as source of seed materials for the dry season, were selected for artificial pollination. To distinguish readily the artificially pollinated ears from the rest of the ears at harvest time, strips of cloth on which were written the row numbers were tied on each stalk.

Method of pollination. In controlled self-pollination work, the tassels or the staminate flowers and the ears of the pistillate flowers were first covered with paper bags tied at the mouth to prevent the entrance of natural agents of pollination. Self-pollination of the bagged ears was accomplished by breaking the lower rachis of the tassels and shaking it over the silk of the ears to be artificially pollinated. After each application the ears were again bagged. Pollination was repeated the next morning. It was generally observed that silking and tasselling did not take place at the same time in all the plants. Bagging was done to accomplish artificial self-pollination of the ears of the lower- and the upper-ear plant used as seeds in the second planting. For a period of two weeks, artificial application of pollen grains was made every morning between six and nine o'clock.

Observation in the field

Percentage of germination. Before the plants in each hill were thinned to one plant to a hill, the percentage of germination in each row was recorded. In determining this percentage, seeds, that may have germinated but the plants did not survive to reach about 30 cm. in height when the counting was made, were not considered.

Frequency of eared and barren plants. Observations on the frequency of two-eared, one-eared and barren stalks and the general stand of the lower, upper and control ear-rows were made during the flowering stage. All pistillate flowers that came out of the leaf sheaths were included.

Harvesting

In the dry-season culture the plants matured in about 94 to 102 days, and in the wet-season in about 114 to 119 days.

The artificially pollinated ears were gathered before the crop was harvested. The ears were harvested, unhusked and piled at the end of each row. Each pile was placed in a separate sack with the original label of the rows. The ears were brought to the laboratory to be air-dried and subsequently weighed.

RESULTS

In table 1 are shown the number of barren, one-eared and two-eared plants in the original field from which the seed materials were obtained for these experiments.

The results of the measurements and computed variation constants of the seed materials for wet and dry seasons are shown in table 2.

Table 3 shows the number of barren, one-eared and two-eared plants in both the dry- and wet-season cultures.

Table 4 presents the percentages of germination and other agronomic characters of lower and upper and control ears in both the dry- and wet-season cultures.

DISCUSSION OF RESULTS

General observations

It was observed in both cultures that there was a marked difference between the time of appearance of the silk of the lower ear and the silk of the upper ear. In general, the silk of the upper ear came out earlier than that of the lower ear. It was also observed in both cultures that, according to the general stand of the plants in the lower ear, upper-ear and control-ear rows, there was relatively no marked difference in vigor.

Agronomic features of lower and upper ears from two-eared plants and the check ears from one-eared plants

In the first planting the primary, upper and control ears differed from one another very markedly in all the characters studied. The difference in length of ear, circumference of ear, shelling percentage and weight of unhusked, weight of husked ears and weight of grains of the control and the upper ears is significant. Likewise, the control ear showed a significant difference in the length, circumference, shelling percentage, weight of unhusked, weight of husked ears and grains from the primary ear. (Table 2.)

As shown in table 2, the second planting materials did not vary much in the characters studied. With the exception of the length of the ears, the differences between the seed-ear from the upper ear-rows are all insignificant for all the characters considered.

The length of the lower ear was 18.11 ± 0.30 centimeters and that of the upper ear, 15.98 ± 0.27 centimeters. The difference between the two means is very significant, indicating that for length of ear, the lower-ear progeny had the advantage in the next generation.

Considering the seed-ears from the control ear-row and the upper ear-row, the differences between their respective means are all significant in all the characters studied, except in the weight of the husked ears. The husked seed-ear from the upper ear-row weighed 123.10 ± 3.59 and the seed-ear from the control ear-row weighed 107.50 ± 2.28 grams. The difference between the means shows significantly the superiority of the secondary ear.

Taking the husked seed-ear from the lower ear-row and the husked seed-ear from the control ear-row, the difference is also significant. The seed-ear from the lower ear-row gave a weight of 118.50 ± 2.84 grams and the control seed-ears, 107.50 ± 2.28 grams. As regards length of ear, the lower seed-ears measured 18.11 ± 0.30 centimeters; the control seed-ear, 15.10 ± 0.27 centimeters. The mean difference is highly significant.

Variation in percentage germination of grains from two-eared and one-eared plants

It may be seen in table 4 that the percentages of germination of the three planting materials also varied. In the first planting the following percentages of germination were obtained: lower ear-seeds, 52.90 ± 1.87 per cent; upper ear-seeds, 60.10 ± 1.70 per cent; the control ear, 61.10 ± 2.11 per cent.

Comparing the percentage germination of the upper ear with a mean of 60.10 ± 1.70 per cent and lower ear with a mean of 52.90 ± 1.87 per cent, a difference of 7.20 ± 2.38 per cent in favor of upper ear was statistically significant. The difference between the control, with a mean of 61.10 ± 2.11 per cent, and the upper ear, is however, insignificant, indicating that an ear from one-eared plant and the upper ear of the two-eared had the same percentage germination. Considering the control ear and the lower, the difference in percentage germination is significant, the control ear being the better. This difference indicates that the one-eared plant had a higher percentage germination than the lower ear of the two-eared plants.

By reference again to table 4, it may be seen that in the wet-season the lower ear gave 50.90 ± 1.80 per cent germination. The upper ear gave 57.01 ± 1.74 per cent and the control ear gave 58.70 ± 0.22 per cent. In the second planting, the difference in percentage of germination between the upper and lower ear was insignificant, but was significant in the first planting. The difference between the control ear and the upper ear is also insignificant, whereas, the difference between the means of the control ear and the lower ear is significantly in favor of the control ear.

It is evident in both cultures that the percentages of germination of the lower ear-seeds were very much lower than that of the upper ear or the control ear-seeds. It was observed that a considerable number of seeds of the lower ear were dull in color; this condition may have been caused by the forced maturity of the ears, that is, plants matured in spite of the late fertilization. The poor germination of lower ear-seed material was also marked in the second planting, suggesting an inherent tendency to low percentage.

Frequency distribution of barren, one-eared and two-eared plants in the progeny of lower, upper and control ear seeds

It is the common belief of farmers, not only in the Philippines but also in other countries, that the production of ears in corn is influenced favorably by vigor of the plant. This may be true to some extent if the plant does not attain a considerable height which favors the production of ears. But it was observed in this work that even vigorous plants failed to develop ears or produce pistillate inflorescence. The failure to produce ears may have been due to poor parentage.

As shown in table 1, out of the 2884 plants studied, there were 312 with barren stalks, 1639 with one ear and 933 plants with two ears. The barren individuals were about the same height as the other plants in the population.

In the first planting, as shown in table 3, there were 1.90 ± 0.12 barren individuals in the lower ear-rows, 1.54 ± 0.27 plants in the upper ear-rows and 1.18 ± 0.11 stalks in the control ear-rows. There is no significant difference in the three comparisons so far as the occurrence of barren stalks is concerned.

In the one-ear character only the difference between the mean of the upper and that of the control ears is significant. The lower ear gave a mean value of 55.74 ± 1.51 plants and the control ear, 50.50 ± 1.74 plants. The other two comparisons gave insignificant difference. With the two-ear character, all the three possible comparisons gave an insignificant difference.

Again in table 3 a different result is recorded from the second planting. The difference between the lower ear and the control is significant as to barrenness. The lower ear had 4.78 ± 0.31 barren stalks and the upper ear, 3.38 ± 0.28 stalks and the control ear, 2.89 ± 0.19 stalks. Comparing the primary ear and the control ear, the difference between the means is also significant while the difference between the control and the upper ear is insignificant. Based on the production of two-ear character all the comparisons gave an insignificant difference. This result would mean that the number of ears to be produced on a corn stalk seems to be not dependent upon whether the original seed material is derived from a lower ear or an upper ear or from a one- or a two-eared plant. There were more barren stalks in the whole field when the plants were not favored by existing conditions, as is shown in table 3. It is very apparent in the dry-season culture, as also shown in table 3, that the number of barren stalks in the whole field was very small. The plants in the first culture were very vigorous and this seemed to be of advantage in the production of ears. But some vigorous plants failed to produce ears or even pistillate flowers, indicating that other factors besides vigor affects the production of ears. In this case failure to produce ears might have been caused by poor parentage. The present result, being only one generation does not seem to warrant comparison with the conclusion of Grabner (1913) who stated that the success was obtained in producing a many-eared variety of corn by selecting seeds from a many-eared strain. The findings of Reitz and Smith (1917) to the effect that no significant difference was found as to the frequency of one-eared or two-eared stalks from seeds from either strain when planted are corroborated by the result of this study that there is no significant difference between one-eared and two-eared plants in the lower and upper ears.

Variation in silking of two-eared plants and its relation to ears formed in the lower, upper and control-ear-rows

In places where green corn finds a ready market, the numbers of ears that develop is of more importance than the weight of the grains. In table 2 on the dry season culture, it is shown that the mean difference of ears harvested from the control ear and lower ear is significant. The lower ear gave a mean value of 66.30 ± 1.79 ears and the control-ear, 71.50 ± 1.90 ears. The difference between the upper ear and lower is, however, not significant.

A different result in comparison is obtained from the wet-season cultures, as may be seen in table 4. The lower ear gave a yield of 27.40 ± 0.80 ears, the upper ear, 30.70 ± 0.90 ears and the control ear, 34.00 ± 1.38 ears. The difference between the upper and the lower is significant. As may be seen in table 3, indicating the number of pistillate inflorescence, and in table 4, indicating the number of ears formed, there was a very low percentage of ear formation. This was because most of the lower ears failed to develop. Three phenomena were observed that would seem to account for the failure of seed formation on the lower ear. First, very late emergence of the inflorescence from the leaf sheath with late appearance of silk. Secondly, failure of grains to develop in spite of the presence of pollen grains, a phenomenon similar to that which Grabner (1913) reported as a case of sterility in many-eared strains of corn. Thirdly, the failure of the inflorescence to develop further after it had sent out its silk.

A comparison of the weights of unhusked and husked ears harvested from the lower, upper and control ear-rows

As shown in table 4, there is a direct relation between the weight of husked ears and of unhusked ears. In the dry season harvest, the unhusked ears of the lower ear-rows gave 7.90 ± 0.26 kgm.; the upper ear-rows gave 8.22 ± 0.23 kgm.; the control ear-rows gave 7.90 ± 0.26 kgm. A similar result was obtained from the weight determination of the husked and the unhusked ears in the second harvest. The direct relation of the weights of husked and unhusked ears may be explained by the fact that the weight of the husk does not depend on the kind of ear produced.

The relation of the weight of grains to the number of ears produced from the lower, upper and control ear-rows

Table 4 shows the relation of the number of ears gathered to the weight of grains to the ear. It is of interest to note that in both cultures there were relatively more ears harvested from the control ear-rows than from the lower and upper ear-rows. But the average weight of grains per ear in the upper ear-row-harvest exceeded the weight of grains per ear in the harvests from either the lower ear or the control-ear-rows. The average weight of grain per ear in the upper ear harvest exceeded the average weight of grain per ear in the lower ear harvest.

The fact that the upper ear yielded more grains than the lower ear further confirms the result of the study of Reitz and Smith (1917).

The relation of shelling percentage to the average weight of grain per ear in the lower, upper and control ear-row

In both the wet and dry season cultures (Table 4) the shelling percentage of the ears harvested from the control-ear-rows exceeded the shelling percentage of the ears harvested from both the lower and the upper ear-rows. In the dry season, the difference between the control and the lower ear is not significant. But in the wet season, the difference between the upper and lower ears is significant. The following shelling percentages were obtained in the wet-season harvest: lower ear, 77.40 ± 0.81; upper ear, 80.50 ± 0.48; and the control ear, 81.30 ± 0.44. The difference between the means of the control ear and the lower ear is also significant.

It may be seen in table 4 that there is no direct relation between the average weight of grains per ear and the shelling percentage. In the first planting, the lower ear gave an average weight of grains per ear of 75.70 ± 2.02 grams with a shelling percentage of 78.28 ± 0.43; the upper ear gave an average weight of grains per ear of 76.50 ± 1.83 with a shelling percentage of 70.00 ± 0.39; the control ear gave an average weight of grains per ear of 71.50 ± 1.63 with a shelling percentage of 78.64 ± 0.50. Likewise, as shown in table 4, the conclusion that there is no direct relation between the average weight of grains per ear and the shelling percentage, seems to hold true.

SUMMARY AND CONCLUSIONS

The experiments here reported were undertaken to study agronomically and to determine statistically the plant breeding value of lower and upper ears borne on two-eared corn stalks. The results obtained may be summarized as follows:

1. The plants that developed from the seeds of the lower, upper and control ears did not differ materially in vigor.

2. The upper-ear seeds yielded more grains than the lower or control-ear seeds (seeds from one-eared plants) when planted. But the control-ear-rows exceeded both the lower and upper ear-rows in the number of ears produced. The lower ear rows produced the least.

3. The seeds from the lower ear had a poorer germination than either the control or upper-ear seeds. The difference in percentage of germination between the control and the upper-ear-seeds was not significant.

4. In most of the plants bearing two ears, the pistillate flowers of the lower ears failed to develop because of the late emergence of silk and because of failure to develop further when it had come out of the leaf sheath.

5. In the two-eared plants, the upper ears generally tended to become very much larger than the lower ears and are to be preferred as source of seed material.

6. The appearance of two-ear character seems not to depend on whether the parent plants were one-eared or two-eared, for when seeds of either ear were planted, no significant difference was obtained as to the frequency of one-eared or two-eared stalks.

TABLE 1

Number of barren one-eared and two-eared stalks of Native Yellow Flint corn in the original field

NUMBER OF EARS ON A STALK	NUMBER OF PLANTS
Barren	312
One	1639
Two	933
Number of individuals studied	2884

TABLE 2

Variability of the ear characters of the lower, upper and control seed materials in the dry-season and wet-season plantings

SEED MATERIALS	CHARACTERS STUDIED	DRY-SEASON PLANTING			WET-SEASON PLANTING		
		Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation
				per cent			*per cent*
Lower ears	Weight of unhusked ears (grams)	71.10 ± 3.45	36.21 ± 2.41	50.93 ± 6.17	137.50 ± 3.63	38.10 ± 2.57	27.71 ± 2.01
	Weight of husked ears (grams)	56.70 ± 3.13	32.85 ± 2.22	58.59 ± 5.13	118.50 ± 2.84	29.77 ± 2.01	25.12 ± 1.80
	Length of ears (cm.)	13.18 ± 0.80	2.89 ± 0.19	22.69 ± 1.61	18.11 ± 0.30	3.10 ± 0.21	17.12 ± 1.19
	Circumference of ears (cm.)	11.01 ± 0.14	1.49 ± 0.10	13.36 ± 0.93	12.85 ± 0.06	0.83 ± 0.06	4.20 ± 0.29
	Weight of grains per ear (grams)	45.50 ± 0.92	9.61 ± 0.65	31.12 ± 1.49	100.10 ± 2.83	29.69 ± 2.00	29.66 ± 2.17
	Shelling percentage	77.74 ± 0.88	9.22 ± 0.62	11.95 ± 0.82	85.56 ± 0.56	5.89 ± 0.40	7.04 ± 0.47
Upper ears	Weight of unhusked ears (grams)	162.90 ± 0.26	2.77 ± 0.19	1.63 ± 0.11	153.70 ± 4.22	4.22 ± 2.98	28.77 ± 2.09
	Weight of husked ears (grams)	141.10 ± 2.68	28.10 ± 1.90	9.91 ± 0.67	123.10 ± 3.59	37.61 ± 2.54	30.55 ± 2.24
	Length of ears (cm.)	18.34 ± 0.19	1.95 ± 0.13	10.64 ± 0.73	15.98 ± 0.27	2.80 ± 0.19	17.49 ± 1.22
	Circumference of ears (cm.)	13.19 ± 0.24	2.51 ± 0.17	19.05 ± 1.33	12.95 ± 0.08	0.83 ± 0.06	4.20 ± 0.29
	Weight of grains per ear (grams)	119.50 ± 2.86	29.98 ± 2.02	21.05 ± 1.48	105.30 ± 3.15	33.10 ± 2.23	31.99 ± 2.37
	Shelling percentage	84.10 ± 0.45	4.71 ± 0.32	5.61 ± 0.38	85.00 ± 0.40	4.24 ± 0.29	4.99 ± 0.34
Control ears	Weight of unhusked ears (grams)	163.13 ± 3.34	35.10 ± 2.37	21.52 ± 1.52	128.65 ± 4.20	44.05 ± 0.97	34.25 ± 2.56
	Weight of husked ears (grams)	133.30 ± 3.09	32.39 ± 2.18	24.29 ± 1.73	107.50 ± 2.28	34.34 ± 2.32	31.94 ± 1.27
	Length of ears (cm.)	17.14 ± 0.23	2.35 ± 0.17	14.28 ± 0.98	15.10 ± 0.27	2.83 ± 0.19	18.76 ± 1.31
	Circumference of ears (cm.)	13.31 ± 0.27	1.33 ± 0.09	10.01 ± 0.68	12.68 ± 0.10	1.01 ± 0.07	7.98 ± 0.54
	Weight of grains per ear (grams)	114.13 ± 2.74	28.68 ± 1.93	25.10 ± 1.80	91.10 ± 3.08	32.32 ± 2.18	35.48 ± 2.68
	Shelling percentage	84.22 ± 0.37	3.83 ± 0.26	4.55 ± 0.31	83.98 ± 0.46	4.82 ± 0.33	5.74 ± 0.39

TABLE 3

Incidence of barren, one-eared and two-eared stalks in the dry-season and wet-season plantings computed from 50 rows

SEED MATERIALS	NUMBER OF EARS ON A STALK	DRY-SEASON PLANTING			WET-SEASON PLANTING		
		Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation
		plants			*plants*	*plants*	*per cent*
Lower ears	0	1.90 ± 0.12	1.27 ± 0.09	66.84 ± 6.20	4.78 ± 0.31	3.23 ± 0.22	67.59 ± 6.32
	1	55.74 ± 1.51	15.83 ± 1.07	78.40 ± 2.06	25.30 ± 0.88	9.18 ± 0.62	36.29 ± 2.75
	2	7.90 ± 0.99	5.95 ± 0.40	61.33 ± 5.89	2.22 ± 0.19	1.96 ± 1.13	88.28 ± 9.52
Upper ears	0	1.54 ± 0.27	1.72 ± 0.13	111.68 ± 8.50	3.38 ± 0.28	2.91 ± 0.20	86.90 ± 2.33
	1	65.70 ± 2.26	2.64 ± 1.46	32.93 ± 2.45	27.70 ± 0.77	8.09 ± 0.55	29.20 ± 2.13
	2	10.30 ± 0.54	5.67 ± 0.38	55.05 ± 3.81	2.65 ± 1.18	1.85 ± 0.12	69.81 ± 6.62
Control ears	0	1.81 ± 0.11	1.10 ± 0.07	93.32 ± 10.40	2.89 ± 0.19	2.01 ± 0.14	69.55 ± 6.58
	1	50.50 ± 1.74	18.25 ± 1.24	36.14 ± 1.61	29.90 ± 1.03	10.84 ± 0.73	33.25 ± 2.75
	2	10.48 ± 0.62	6.50 ± 0.44	62.03 ± 5.52	1.86 ± 0.12	1.12 ± 0.08	59.56 ± 5.20

TABLE 4

Variability in percentage germination and other agronomic characters of the lower, upper and control ears in the dry-season and wet-season plantings

SEED MATERIALS	CHARACTERS STUDIED	DRY-SEASON PLANTING			WET-SEASON PLANTING		
		Mean	Standard deviation	Coefficient of variation	Mean	Standard deviation	Coefficient of variation
				per cent			*per cent*
Lower ears	Percentage germination	52.90 ± 1.87	19.59 ± 1.32	3.70 ± 0.25	50.90 ± 1.80	18.89 ± 1.27	34.38 ± 2.58
	Number of ears harvested	66.30 ± 1.79	18.75 ± 1.26	28.78 ± 2.05	27.40 ± 0.80	8.40 ± 0.57	30.67 ± 2.25
	Weight of unhusked ears (kgm.)	7.90 ± 0.26	2.71 ± 0.18	34.34 ± 2.57	1.01 ± 0.07	0.75 ± 0.05	73.86 ± 7.20
	Weight of husked ears (kgm.)	5.90 ± 0.19	2.04 ± 0.14	34.57 ± 2.60	0.95 ± 0.02	0.18 ± 0.01	19.89 ± 1.94
	Weight of grains (kgm.)	4.95 ± 0.15	1.55 ± 0.10	31.36 ± 2.31	0.73 ± 0.01	0.36 ± 0.02	49.49 ± 4.07
	Average weight of grains per ear (grams)	75.70 ± 2.02	21.21 ± 1.43	28.02 ± 2.03	26.80 ± 0.88	9.25 ± 0.62	34.47 ± 2.59
	Shelling percentage	78.28 ± 0.43	4.54 ± 0.31	5.80 ± 0.39	77.40 ± 0.81	8.50 ± 0.57	10.71 ± 0.73
Upper ears	Percentage germination	60.10 ± 1.70	17.80 ± 1.20	2.96 ± 0.20	57.01 ± 1.74	18.26 ± 1.23	32.02 ± 2.37
	Number of ears harvested	69.10 ± 1.72	18.03 ± 1.22	26.09 ± 1.90	30.70 ± 0.90	9.40 ± 0.63	30.62 ± 2.25
	Weight of unhusked ears (kgm.)	8.22 ± 0.28	2.91 ± 0.20	35.34 ± 2.66	1.38 ± 0.05	0.54 ± 0.04	46.14 ± 3.72
	Weight of husked ears (kgm.)	6.46 ± 0.23	2.38 ± 0.16	34.76 ± 2.79	1.12 ± 0.04	0.45 ± 0.03	40.38 ± 3.40
	Weight of grains (kgm.)	5.31 ± 0.20	2.07 ± 0.40	38.94 ± 3.00	0.90 ± 0.04	0.41 ± 0.03	45.54 ± 3.65
	Average weight of grains per ear (grams)	76.50 ± 1.83	19.21 ± 1.30	25.11 ± 1.80	29.30 ± 0.70	7.34 ± 0.50	20.03 ± 1.79
	Shelling percentage	77.50 ± 0.37	4.04 ± 0.27	5.21 ± 0.35	80.50 ± 0.49	5.12 ± 0.35	6.36 ± 0.43
Control ears	Percentage germination	61.10 ± 2.11	22.11 ± 1.49	3.61 ± 0.24	58.70 ± 0.22	23.10 ± 1.56	39.35 ± 3.04
	Number of ears harvested	71.50 ± 1.90	19.90 ± 1.34	27.91 ± 2.02	39.00 ± 1.38	14.49 ± 0.98	37.14 ± 2.83
	Weight of unhusked ears (kgm.)	7.90 ± 0.02	2.71 ± 0.18	34.34 ± 2.57	1.10 ± 0.04	0.40 ± 0.03	39.90 ± 3.09
	Weight of husked ears (kgm.)	5.98 ± 0.19	1.94 ± 0.13	32.46 ± 2.41	1.02 ± 0.05	0.53 ± 0.04	59.59 ± 4.31
	Weight of grains (kgm.)	5.07 ± 0.16	1.67 ± 0.11	32.88 ± 2.45	0.79 ± 0.04	0.40 ± 0.03	50.63 ± 4.20
	Average weight of grains per ear (grams)	71.50 ± 1.63	17.09 ± 1.15	23.88 ± 1.78	26.20 ± 0.79	8.23 ± 0.56	31.42 ± 2.32
	Shelling percentage	78.64 ± 0.50	5.22 ± 0.35	6.63 ± 0.45	81.30 ± 0.44	4.57 ± 0.31	5.62 ± 0.38

MORPHOLOGY OF THE FLOWER, FRUIT, AND SEED OF RAPHANUS SATIVUS LINNAEUS[1]

MARTINIANO E. ROSELL

WITH THREE PLATES

INTRODUCTION

As with most plants the solution of many problems associated with radish growing lies in the field of plant breeding. Any attempt to solve these problems through breeding requires a knowledge of the morphology of its flower. It was for the purpose of knowing the floral structure and development of its floral parts, fruit and seed that the work reported in this paper was undertaken. An attempt to grow pollen grains *in vitro* was made. While the findings reported in this study may not be the answer to all the intricate problems connected with the improvement of this vegetable crop, they may, at least, prove of value as a basis on which to plan any future hybridization program with this plant.

Golinska (1929) worked on the morphology of the mature root of radish. Sutaria (1930) gave an account of the microsporogenesis in *Raphanus sativus* and reports nine bivalent chromosomes in the pollen mother cells of Indian radish at diakinesis. Kakizaki and Kasai (1933) worked on bud pollination in cabbage and radish, and they found that by bud pollination fertility in selfing is not decreased at all. On the contrary, fertility is increased, especially in plants which are highly self-incompatible.

Investigations on the family Cruciferae are numerous. In summarizing the characteristics of the family Cruciferae, Schnarf (1931) wrote that the pollen grains are trinucleate in *Draba, Biscutella, Cardamine, Ionopsidium,* and *Hesperis*. Division of the pollen mother cells is simultaneous and the tetrads become separated by invagination or furrowing. The megasporange possesses rather thick nucellus and is bitegumentary. In *Alyssum macrocarpum* and *Lunaria annua* there was found the formation of parietal tissue but in other investigated species no parietal cell was formed. A single embryo sac mother cell is developed in *Thlaspi arvense, Barbarea vulgaris,* and *Draba verna,* while several mother cells are formed in *Capsella bursa-pastoris, Sisymbrium* spp. and *Cardamine* spp. The development of the embryo sac in the family is normal, the antipodals of which are small and ephemeral; in the majority of cases these are hardly visible at maturity of the sac so that one finds difficulty in securing 8-nucleate sac. The synergids (*Ionopsidium*) have filiform-apparatus and are ridged. Double fertilization was observed in *Capsella bursa-pastoris, Cardamine pratensis, Draba verna, Lepidium sativum* and *Sisymbrium thalianum.* The development of the nuclear endosperm is normal, and at a later stage, usually a large vescicle containing free, dividing, hypertrophied nuclei lying in the thick protoplasmic mass at the chalazal end of the sac is formed. The development of the embryo has been traced in *Capsella bursa-pastoris.*

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[1] Thesis presented for graduation, 1936, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture, No. 506; Experiment Station contribution No. 1142. Prepared in the Department of Plant Physiology under the direction of Dr. J. B. Juliano.

MATERIAL AND METHODS

The material used in this study was obtained from plants grown in the Rural High School garden and from plants grown in large earthen pots near the Plant Physiology Laboratory. The plants were grown from seeds bought in a Chinese store in Calamba, Laguna Province.

Inflorescences, flowers, fruits and seeds in different stages of development were gathered at various intervals from March 23, 1935 to November, 1935. These materials were fixed in the field and in the laboratory with the use of formalin-acetic-alcohol solution (70 per cent) prepared according to the formula given by Chamberlain (1932). The material was treated as usual and embedded in paraffin. Sections 8 to 10 micra thick were prepared and most of them were stained with the use of Haidenhain's iron-alum haematoxylin with Orange Gold dissolved in clove oil as counterstain.

From January 10 to 25, 1936, attempts were made to determine the best concentration of cane sugar solution for germinating pollen grains *in vitro.* Hourly germinations of pollen grains gathered from the time of dehiscence up to 5:00 p. m. (using the percentage of cane sugar solution found best for germinating the pollen grains) were tried by the writer.

RESULTS OF OBSERVATION

The flower

Description. The perfect, or hermaphroditic, flowers are borne on a large, branched, indeterminate or racemous cluster which is terminal or lateral. Each individual flower, which measures from

1.5 to 2 centimeters long, is borne vertically on a fairly long, green, terete, glabrous pedicel, 1-1.5 centimeters long and about 1 millimeter in diameter. The sepals are four, free, erect, and cream to pale green in color; the two outer sepals are narrow and slender, but the two inner ones are broader and saccate at the base. The four petals are so arranged that when viewed from above they have the appearance of a Greek cross, hence the name Cruciferae (Robbins, 1931) ; they are similar in size and form, spatulate-geniculate and clawed; that is, they have a narrow or stalk-like base with broad lobe or rounded apex, light purple but darker along the margin of the corolla and the veins. Nectar glands are present at the base of the petals. Stamens six, arranged in a single whorl (pl. 2, fig. 15). Two of the stamens with short, terete, white filaments are opposite each of the two inner sepals. The other four are opposite the petals. The anther is introrse, cream, turning yellow at dehiscence, and is attached to the filament at its basal end, 4-lobed, 4-celled with longitudinal dehiscence. The superior pistil is small, slender, and pale green; the ovary tubular, though somewhat constricted, glabrous, 2-celled; megasporanges small, 8-10 in number, atropous at first and later, campylotropous, borne alternately or in pairs on two longitudinal parietal placentae (pl. 1, fig. 6), which are connected by a "false" partition, an outgrowth of the placentae themselves (pl. 1, fig. 8-9) ; style slender, glabrous, pale green; stigma yellowish to pale green, disc-shaped and bilobed.

Pollen germination. Artificial germination of plant pollen, which has an important bearing in connection with the pollination and fertilization of plants, is very well worked out and has met with varying success. Many artificial media have been tried by different workers. Mohl in 1834, as cited by Anthony and Harlan (1920), was able to germinate pollen in water. Most investigators, however, germinate pollen grains with success in sugar solutions of different osmotic concentrations. Pearson (1933), for example, was able to successfully germinate pollen of *Brassica oleracea* in 20 per cent sucrose solution at 15°–20°C. Stout (1931), on the other hand, germinates pollen of this same plant in a medium made up of 100 cc. water, 2 grams agar agar and 15 grams cane sugar.

The writer tried to germinate pollen of *Raphanus sativus* artificially in cane sugar solutions of different concentrations; namely, 0.25, 0.5, 1.0, 3.0, 5.0, 7.0, 9.0, 11.0 and 13.0 per cent. It was found that the pollen grains germinate best in close proximity to 1 per cent sugar solution (pl. 2, fig. 28). Solutions below or above this concentration proved unfavorable for the growth of the pollen tube.

The pollen grains either did not grow at all or they burst out in solutions of high concentration. In some instances, however, the pollen grains which were germinated in a solution of high concentration, formed small knobs which enlarged as the microspores imbibed water. This bulging of the intine was also noted in barley pollen by Anthony and Harlan (1920), who also report that high concentrations resulted in plasmolysis and low concentration in busting.

No attempt was made in this study to preserve radish pollen for a considerable length of time, but it was thought an insight as to how long after dehiscence pollen will respond to artificial treatment with 1 per cent cane sugar solution might be of interest. Accordingly, a newly opened flower was tagged one bright sunny morning (January 25, 1936). As its anthers began to dehisce at 7:00 a. m., pollen grains were obtained with a dissecting needle and germinated *in vitro,* using the hanging drop method. Hourly collections of pollen from the anthers of this same flower were made from 7:00 a. m. to 5:00 p. m. at which time very few pollen grains were left in the anthers. Results from the hourly germination tests showed that pollen grains collected at 9:00 a. m. gave a higher percentage of germination than any of the pollen grains collected at any other time of the day. Those pollen grains collected at 7:00 a. m., just after dehiscence, and those at 8:00 a. m. also gave good germination, but those collected long after 9:00 a. m., did not germinate at all, clearly indicating that they were no longer viable. From the result of these germination trials it may be reported that radish pollen remains viable for only a very short time after dehiscence and that the period of highest germinability is about 2 hours after the microspores are dehisced. No pollen samples from flowers opening at 10:00 a. m. were germinated so that no definite statement can be given as to the actual length of time their pollen grains could remain viable after dehiscence.

Organography. The flowers of radish are borne on a branched, lateral or terminal, indeterminate inflorescence. The floral primordium emerges as a lateral or terminal rounded protuberance from the growing point of a branch of the inflorescence (pl. 1, fig. 1). Soon, protuberances are formed near the margin (pl. 1, fig. 2), of the floral primordium, and these emerge as a single whorl of small papillae. These are the four sepals, which elongate upward and at the same time bend inward (pl. 1, fig. 3), giving a protection to the growing apex of the young flower. The next floral organs to differentiate are the 6 stamens arranged in a single whorl which arise as protuberances on the marginal surface of the protected apex (pl. 1, fig. 3). As the stamens grow and elongate, the carpels are next formed and these arise from the growing apex between the the whorl of stamens (pl. 1, fig. 4-6). The last cycle of floral organs to appear are the 4 petals which are first evidenced as papillate swellings between the whorl of sepals and that of stamens (pl. 1, fig. 5-6). At the time the petals are formed, the primordia of the megasporanges are already differentiated in the carpels. The petals develop rapidly and with the developing carpels and stamens create a pressure which forces the sepals apart prior to anthesis.

The order of appearance of the different floral organs of radish, therefore, deviates from the usual acropetalic succession characteristic of many cyclic flowers. The different floral parts appear in the order of sepals, stamens, carpels, and petals. In this case there is an acropetalic succession of certain cycles followed by a basipetal succession of the remaining cycle, that of the petals. This same order of development of floral organs was reported for *Capsella* (Coulter and Chamberlain, 1903) and *Brassica oleracea* Linn. (Thompson, 1933), a feature which is perhaps peculiar to the family Cruciferae. Among Compositae, Dipsaceae, Valerianaceae, and Rubiaceae where the sepals are very much reduced or modified, their primordia do not appear until after those of the stamens and carpels (Coulter and Chamberlain, 1903). In *Astilbe*, for example, Webb (1902) found that the order of succession of floral cycles is sepals, inner stamens, carpels, outer stamens and petals. Pfeffer (1872) noted that the primordia of petals in Primulaceae appear after those of the stamens and each apparently from the dorsal surface of a young stamen. It is apparent, therefore, that such variety of methods of development of floral organs demands a more or less serious systematic investigation so that their significance could be ascertained.

Megasporange and megagametophyte

Megasporange. Several theories have been advanced to describe the ovary in Cruciferae but the generally accepted one is that it is made up of two carpels. Eames and Wilson (1928), however, agree with the idea of polymorphic carpels where the valves are assumed to be the "sterile" carpels whose margins are fused into two solid "fertile" carpels that form the long style and the stigma. They believe that there are two kinds of carpels in the Cruciferae; a valve or "sterile" carpel and a solid or "fertile" carpel which are arranged in two whorls of two carpels each. The outer whorl is made up of two valve-like open carpels bearing no ovules and the outer whorl consists of two solid or closed, ovule-bearing carpels.

The simple pistil in radish is long and slender with two-celled ovary. There are 8 to 10 ovules arranged in two rows and these arise from the placentae near their junction with the ovary wall, hence placentation is parietal (pl. 1, fig. 8-9).

The primordia of the megasporanges can be distinguished long before the petals have fully developed (pl. 1, fig. 6), and the primordia arise as conical projections from the placentae. Each of these protuberances of actively growing tissue forms the rudimentary nucellus to a nascent ovule. Thompson (1933) found the same origin of the megasporange in cabbage. The megasporange, which is atropous at first, enlarges by cell division, but owing to a one-sided growth, it becomes bent upward, its micropyle directed towards the stigma especially at maturity (pl. 1, fig. 7).

The integuments are recognizable at the time the archesporium is fully differentiated on its nucellus (pl. 1, fig. 10-11). These appear as two concentric rings of actively growing tissue at the base of the nucellus, and these differentiate almost simultaneously, the inner ring generally a little before the outer. These integuments grow rapidly and soon enclose the whole nucellus.

Megaspore mother cell. At the time the two integuments are fairly differentiated, the archesporium is fully developed at the summit of the nucellus (pl. 1, fig. 10). This consists of several (4 to 6) large, elongated, hypodermal cells containing dense cytoplasm with large, rounded, dark-staining nuclei and usually lying side by side. The development of multicellular archesporium in radish is duplicated by *Brassica oleracea* L. (Pearson, 1933) and *Capsella bursa-pastoris, Sisymbrium* sp., and *Cardamine* sp. (Schnarf, 1931). However, Thompson (1933), working in Virginia, found one- or two-celled archesporium in *Brassica oleracea.*

Only one cell of the multicellular archesporium functions as a megaspore mother cell. This cell is usually found towards the inner portion of the nucellus (pl. 1, fig. 11). The functional megaspore mother cell continues to develop and enlarge, while the rest of the archesporial sister cells remain passive, gradually becoming crescent-shaped as they are pushed aside or digested by the enlarging megaspore mother cell. At this stage, the megaspore mother cell is oblong, broader towards the micropyle and contains dense cytoplasm and a large, rounded nucleus. Soon, it enters synapsis (pl. 1, fig. 11-12), and by two successive cell divisions, a linear tetrad is formed (pl. 1, fig. 13 and pl. 2, fig. 16). However, a linear row of three megaspores (pl. 1, fig. 14) is not uncommon, owing to the inactivity of the micropylar sister megaspore resulting from the first division of the megaspore mother cells. Only one of the daughter megaspore cells, usually the one towards the chalaza, survives to give rise to the embryo sac. The rest of the cells degenerate and appear as groups of dark-staining irregular patches towards the micropylar region (fig. 2, fig. 16). The chalazal daughter megaspore enlarges and continues to develop until finally it occupies the whole nucellus, the other cells having been completely degenerated and digested.

Megagametophyte. The embryo sac experiences a very rapid enlargement. At synapsis of the nucleus of the functional megaspore (pl. 2, fig. 16), the embryo sac is more or less oblong, with its chalazal end tapering somewhat to one side. After the first division of its nucleus is over, the embryo sac further enlarges and becomes more or less oblong, its chalazal end smaller (pl. 2, fig. 17). The daughter nuclei remain at the middle of the sac for some time and vacuoles are evident. Soon, the two nuclei migrate each to the opposite pole (pl. 2, fig. 18) and a large central vacuole is thus developed, the cytoplasm becoming much more dense at both ends of the sacs. By two more successive divisions of these two nuclei (pl. 2, fig. 19-20), a normal 8-nucleate megagametophyte is thus formed.

The mature sac contains only four cells; the antipodals are usually absent (pl. 2, fig. 21). In fact, the writer did not observe the presence of antipodals in the numerous preparations he made of the mature embryo sac before anthesis. This ephemeral character of antipodal cells was considered by Schnarf (1931) as a character of the family of which *Raphanus* is no exception to the rule.

The two polar nuclei usually lie at the center of the sac (pl. 2, fig. 21), each possessing large nucleolus and dense nucleoplasm.

The egg apparatus consists of two synergid cells and one megagamete. The synergids are more or less pyriform in shape and each has a dense cytoplasm and a small nucleus. Vacuolation is evident near the apex. The nucleus usually lies on one side near the middle portion of the cell. The filiform-apparatus is not evident as it is in *Ionopsidium* and *Capsella* (Schnarf, 1931).

The megagamete lies behind and between the two synergids (pl. 2, fig. 21) and seems to possess no distinct vacuole. The nucleus lies at its distal end, and is rounded with large nucleolus and dense nucleoplasm. The occurrence of two megagametes in an embryo sac was observed by Artschwager and Starrett (1933) in sugar beet. They believe, however, that the extra egg is the sister nucleus of the synergid since only one synergid accompanies the two megagametes.

Microsporange and microspore

The stamens are first differentiated on the floral primordium as a ring of six tubular projections (pl. 1, fig. 3-5) inside the whorl of sepals. These elongate upward and very early form their elongated anthers and rather long, slender filaments. In transverse section the young anther is more or less rounded, turning trapezoidal with corners rounded, and consists of isodiametric, meristematic cells surrounded by a distinct layer of epidermal cells. Soon, the anther becomes 4-lobed, each lobe forming a distinct microsporange.

Under each of the four lobes, a row of 2 to 3 hypodermal cells (pl. 2, fig. 22) extending throughout the whole length of the anther differentiates very early; that is, before the primordia of the megasporanges have developed. These hypodermal cells function as the archesporium and are easily distinguished from the rest of the surrounding cells by their dense cytoplasm, large nuclei and their affinity to stains. By a single periclinal division, these cells give rise to an outer layer (primary parietal cells) and inner layer (primary sporogenous) of cells similar to that obtaining in the anther of cabbage (Thompson, 1933). The outer layer of cells by anticlinal and periclinal divisions (pl. 2, fig. 22-23) forms a thin parietal tissue consisting of three layers of cells. The outermost layer of the parietal tissue functions as the endothecium, and the innermost, the tapetum; the middle layer usually undergoes degeneration during the subsequent development of the anther.

The primary sporogenous cells or inner layer divide in all directions until a mass of polyhedral, dark-staining microspore mother cells in the center of the microsporange is formed. The cytoplasm of each microspore mother cell usually condenses towards the center of each cell just before or during the division of their nuclei. Soon, the microspore mother cells enter synapsis (pl. 2, fig. 24) and together with the tapetum separate from the parietal tissue. By two simultaneous divisions, the microspore mother cells form the tetrads. Kakizaki and Kasai (1933) were able to count 9 bivalent chromosomes in the radish plant they worked on in Japan. In figure 25, plate 2, are shown two microspore mother cells at the telophase stage of their heterotypic division. According to Schnarf (1931), the tetrads in the family Cruciferae are separated by furrowing or invagination. Upon separation, the young microspore is at first thin-walled, later becoming thick-walled with distinct thickening on its walls. It has three eccentric corners (pl. 2, fig. 27), but at maturity it becomes nearly rounded (pl. 2, fig. 28).

The tapetum consists of a single row of cells derived from the innermost layer of the parietal tissue. These cells are easily differentiated from the microspore mother cells by their dense cytoplasm and rather large nuclei. They are more or less rectangular to trapezoidal in shape, and are arranged in a ring surrounding the whole mass of microspore mother cells inside the microsporange. The tapetal cells are at first uninucleate, but as the microspore mother cells enter synapsis they become binucleate (pl. 2, fig. 26) by simple mitotic divisions of their nuclei similar to that found in cabbage (Thompson, 1933) and many other plants (Coulter and Chamberlain, 1903). Juliano and Alcala (1933), who also found binucleate tapetal cells in *Musa errans* (Blanco) Teodoro var. *botoan* Teodoro, cite similar behavior of tapetal cells in *Musa basjoo* by White in 1928. Binucleate tapetal cells are also found in *Typha latifolia* (Schaffner, 1897), *Eichornia crassipes* (Smith, 1898), and *Lactuca sativa* (Jones, 1927). Cooper (1931) observed nuclear divisions in the tapetal cells of *Capsella bursa-pastoris*. The same was found to be true in *Mangifera indica* (Juliano and Cuevas, 1932). It seems that occurrence of binucleate tapetal cells is present among very widely related plant species of the plant kingdom, and this character has perhaps no phylogenetic significance at all.

The tapetal cells in radish persist during meiosis but as the young microspores are liberated from their tetrad stage, these tapetal cells begin to show signs of degeneration. Little by little they are absorbed by the developing microspores.

The outermost layer of the parietal tissue (endothecium) also undergoes differentiation during the development of the microspores. These cells enlarge, and at the same time crush and press on the middle layer of the parietal tissue. At maturity of the anther, and prior to and at dehiscence, the endothecial cells have attained their maximum size, and each of them possesses numerous radial bands of thickenings on their walls, a feature identical with that reported in cabbage by Thompson (1933). At this stage the epidermis on the microsporange has remained parenchymatous.

The fruit

Description. Soon after fertilization, the perianth and the stamens of the flower dry up and fall off and nothing remains except the single slender pistil. This pistil develops to form the fruit. The fruit, which is an indehiscent pod, is borne upward on a fairly long pedicel; lanceolate, acuminate, and capped with a long conic beak which equals half the whole length of the pod itself. It is somewhat constricted between the seeds, and measures from 5 to 6.5 centimeters in length and 1 centimeter in diameter on its largest portion; 1- to 5-seeded, rarely 7; fleshy, cream to pale green when young but corky and spongy, yellowish to ash-gray when fully ripe.

Locally, the fruit of radish has no food value. Constantino (1917), however, cites that in India, radish is cultivated not only for its root, but also for its seed pods and leaves all of which are eaten. The green pods are boiled or cooked in curries and sometimes pickled. On distillation with water, the seeds yield a colorless sulphuraceous oil which is used in India as medicine.

Pericarp. Long before the perianth segments and the stamens of the flower have been shed, the ovary wall of the pistil consists of a homogeneous mass of parenchymatous, more or less isodiametric cells, delimited on both sides by distinct layers of rectangular to squarish epidermal cells (pl. 3, fig. 29). In the longitudinal section of the pericarp the ground cells are elongated, especially the inner epidermal cells (pl. 3, fig. 30). The ovary wall is traversed by distinct vascular bundles (pl. 3, fig. 29, 32, 34).

The first sign of differentiation in the ground cells of the ovary wall is the enlargement of the hypodermal cells beginning with the fourth layer from the outer epidermis (pl. 3, fig. 31); the inner epidermal cells, as well as the layer just below it, show enlargement only in one direction, the longitudinal. Thus, the ovary can be divided into three regions; namely, (*a*) the outer epidermis with three hypodermal layers consisting of rectangular to squarish parenchyma in longitudinal section (pl. 3, fig. 30-31), (*b*) five to six layers of enlarged isodiametric to rectangular parenchyma, and (*c*) a row or two of longitudinally elongated cells delimited inside by the inner epidermis. This change usually occurs at the time the megagametophyte is at the four-nucleate stage.

Later, the pericarp of the fruit attains its complete differentiation as it approaches maturity.

(*1*) *Outer region of pericarp.* The outer region of the nearly mature pericarp consists of the outer epidermis below which are small, thin-walled parenchyma, three to even as many as six layers, with distinctly tapering end walls (pl. 3, fig. 32, 34). They seem to be undergoing compression from the enlargement of the cells from the middle region of the pericarp, and their walls become highly cuticularized.

(*2*) *Middle region of pericarp.* The middle region of the pericarp consists of enlarged parenchyma, which become spongy with their walls slightly cuticularized. These cells usually break up at maturity of the pod and as the pod becomes dry these disintegrating middle cells give rise to abundant air spaces, contributing greatly to the spongy nature of the dry pod.

(*3*) *The innermost region of the pericarp.* The innermost region of the pericarp consists of only two layers of cells, the inner epidermis and a single hypodermal layer of cells. The inner epidermis which is at first composed of large rectangular cells (pl. 3, fig. 31), experiences compression and stretching owing to the growth of the pericarp. Consequently, its cells elongate transversely (pl. 3, fig. 33, 35), and their walls are a bit thickened. The hypodermal layer of cells remains longitudinally elongate and prosenchymatous. In transverse section they are more or less rounded. Their walls are highly thickened and lignified.

The septum. The septum, which is composed of large parenchyma at its juvenile stage, becomes spongy at maturity of the fruit. It usually undergoes compression resulting from the growth and enlargement of the seeds and at maturity of the fruit this septum is almost obliterated. At regions where it can be clearly differentiated, it appears to be a thin, hyaline mass of spongy cells.

The seed

Description. The mature seed of radish which is borne irregularly in the pod is rather small, yellowish brown to brownish red, more or less rounded with the two sides flattened and with compressed micropyle. Covering the seed is a well developed leathery seed coat which is minutely tuberculate. Within the seed coat is the embryo, which constitutes the largest portion of the seed. This embryo consists of a pair of cotyledons which are folded one over the other, a tiny plumule and a stout radicle. The endosperm is lacking in the mature seed, hence it is exalbuminous. On one end of the seed may be seen, when looked at with a hand lens, a small spot made of the hilum and the micropyle.

Seed coats. The seed coats are thin, but somewhat hard and tuberculate. These coats are rather yellowish brown to brownish red and they consist of cells derived from the integuments of the megasporange.

In the young megasporange the integuments begin to differentiate about the time it begins to show unequal growth. When the megaspore mother cell is in synapsis (pl. 1, fig. 10-11), the two integuments are fully differentiated. The inner integument consists of 2 to 3 layers of cells which are more or less isodiametric. The outer integument possesses only 3 to 4 layers of cells. As the megasporange enlarges, the two integuments rapidly grow and soon form a massive cover to the scanty nucellus of the juvenile megasporange. This growth is usually evident at the time the functional daughter megaspore (uninucleate megagametophyte) begins to enlarge. At this stage of the developing megasporange, the inner integument still consists of 2 to 3 layers of cells at its lateral portion, but at the micropyle it may have up to 5 or more layers of cells. The outer integument, on the other hand, has only 3 to 4 layers of large parenchyma which are much vacuolated.

At the time the seed has attained a size of 600 micra in length and 325 micra in thickness the seed is covered by two distinct coats derived from the two integuments. The outer coat at the lateral portion of the seed consists of a distinct epidermal layer of small, rectangular to squarish cells below which are two to three layers of large parenchyma (pl. 3, fig. 36). Delimiting the outer coat towards the nucellus is a layer of sclerified, thick-walled cells of the inner coat. Below this sclerified layer is a row of enlarged parenchyma, and this is bordered on the inside by the nucellus. The last two tissues form the inner coat.

At the micropylar portion of the seed the outer coat consists of a tangentially flattened epidermis, and 2 to 3 layers of vacuolated parenchyma below which is a mass of tissue consisting of small isodiametric cells forming a huge cap to the micropylar end of the seed and a part of the raphe. This outer coat is delimited on the inside by a layer of heavily sclerified layer of cells and the inner enlarged parenchyma of the inner coat.

At maturity of the seed, the cells of the seed coats undergo further enlargement and differentiation. The epidermis of outer coat now consists of elongated tangentially flattened, rather thick-walled and cuticularized cells. Below this epidermis are 2 to 3 layers of hypodermal parenchyma (pl. 3, fig. 37); the epidermis and the large hypodermal parenchyma are derived from the outer integument of the megasporange.

Below the derivatives of the outer integument is the inner seed coat consisting of (1) small, thick-walled, sclerified cells which have their long axes perpendicular to the circumference of the seed and form a supporting layer to the coat, and (2) longitudinally elongated, rectangular cells which are more or less pigmented (pl. 3, fig. 37). Immediately under and adhering to the pigmented cells are 1 to 2 layers of parenchyma which are all that remains of the nucellus. The two layers of cells referred to above are derived from the inner integument.

At some time in the development of the seed, the storage of food becomes relegated to the coats, but as the seed approaches maturity the starch grains stored in the seed coats are withdrawn and are deposited in the cotyledons of the embryo.

Nucellus. The nucellus of the nascent megasporange (pl. 1, fig. 10-11) is rather poorly developed. In fact all the hypodermal cells at the apex of the nucellus at one time or another function as archesporium, although only one of them gains ascendancy over the others which undergo degeneration. As the megasporange enlarges and elongates, the megagametophyte is carried upward, and a certain amount of nucellar cells become manifest. This enlargement of the nucellus becomes manifest as the young seed approaches maturity, only to be absorbed to a large extent but not wholly by the developing embryo. At maturity of the seed, a layer or two of the nucellus remains adhering to the seed coat (pl. 3, fig. 37).

Embryo. Several stages of the young embryo, which were all incomplete, were obtained by the writer, so that a description of the embryo cannot be given. It may be of interest, however, to state that they seem to agree fairly well with that described for *Capsella* (Souèges, 1919) and cabbage (Thompson, 1933). The young embryo is globular with a long uniseriate suspensor.

Endosperm. The endosperm of radish which is completely absorbed by the embryo is of the nuclear type, and therefore, follows the general trend of development of endosperm in the family (Cruciferae) to which it belongs.

SUMMARY AND CONCLUSIONS

The development of the flower, gametophytes, fruit and seed of radish (*Raphanus sativus* Linn.) which bears light purple flowers, is herein described.

Artificial germination of microspores *in vitro* seems to show that the best solution in which to grow them is 1.0 per cent sugar solution. Microspores from the set of flowers opening at 7:00 a. m., exhibit good germination up to 9 a. m.; no germination was obtained later than that.

The floral organs develop in the following sequence: sepals, stamens, carpels, petals.

On the campylotropous megasporange, multicellular archesporium is developed, only one of the archesporial cells becoming functional. The functional megaspore mother cell divides twice and gives rise to a linear tetrad, the innermost of which forms the normal sac.

The 2- to 3-celled archesporium from the microsporange differentiates from the first layer of hypodermal cells from which are derived the parietal and a mass of microspore mother cells. The development of the microspore seems to be normal.

The pericarp of the fruit becomes spongy and presents three distinct morphological regions.

The endosperm is of the nuclear type and the development of the zygote appears to follow the general trend shown by a majority of species of Cruciferae.

The mature seed coats are derived from the two integuments. The outer integument gives rise to the outer seed coat composed of an epidermis and two to three layers of large parenchyma. The inner integument contributes to the formation of the inner seed coat which consists of a single layer of sclerified thick-walled cells, and a row of large, parenchymatous, pigmented cells.

The nucellus is scanty, but at some time in the development of the seed it becomes somewhat voluminous, only to be absorbed by the embryo during its development. Only two layers of cells of the nucellus remain in the mature seed.

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EXPLANATION OF PLATES

Parts of the flower, the fruit and the seed are designated as follows: (*c*) carpel, (*e*) megagamete or egg, (*fp*) floral primordium, (*ii*) inner integument, (*l*) locule, (*m*) ovule or megasporange, (*oc*) outer coat, (*oi*) outer integument, (*ow*) ovary wall, (*p*) petal, (*pl*) pigmented layer, (*pn*) polar nuclei, (*pt*) parietal tissue, (*s*) sepal, (*sl*) supporting layer, (*spt*) sporogenous tissue, (*st*) stamen, (*sy*) synergid, (*vb*) vascular bundles.

PLATE I

Fig. 1. Longitudinal section of a portion of the inflorescence showing the growing central apex and young floral primordia. × 53.

Fig. 2. Longitudinal section of a single floral primordium showing the beginnings of the sepals. × 99.

Fig. 3. Longitudinal section of an older floral primordium showing the sepals and stamens. × 99.

Fig. 4. An older flower showing the sepals, stamens and pistil fully differentiated. × 53.

Fig. 5. A still older flower showing all its parts fully differentiated. × 53.

Fig. 6. A very much older flower showing the megasporanges in the pistil emerging from the placentae. × 53.

Fig. 7. Diagram of a longitudinal portion of the pistil showing the position of the megasporanges. × 23.

Fig. 8. Diagram of a transverse section of the ovary showing the number of loculi and attachment and arrangement of the megasporanges. × 53.

Fig. 9. Diagram of a transverse section of the same ovary (fig. 8) showing a different attachment of the megasporange. × 53.

Fig. 10. Young megasporange showing its juvenile outer and inner integuments, and its multicellular archesporium. × 540.

Fig. 11. Showing young megasporange with one of the archesporial cells gaining ascendancy over its sister cells. Note the sequence of development of the integuments. × 540.

Fig. 12. Detailed drawing of the functional megaspore mother cell from fig. 11. × 1060.

Fig. 13. Dyad. × 1060.

Fig. 14. Showing a row of three megaspore cells, lowermost of which becomes functional. × 1060.

PLATE II

Fig. 15. Diagram of the transverse section of a nearly mature flower showing relative positions of all its parts. × 23.

Fig. 16. Uninucleate megagametophyte with its nucleus in synaptic stage; note the degenerating micropylar sister megaspore cells. × 1060.

Fig. 17. Binucleate megagametophyte; note shape and position of the nuclei. × 540.

Fig. 18. Binucleate megagametophyte showing polarity; note large central vacuole. × 490.

Fig. 19. Quadrinucleate megagametophyte. × 890.

Fig. 20. Octonucleate megagametophyte. × 490.

Fig. 21. Mature megagametophyte showing polar nuclei and the egg apparatus. × 540.

Fig. 22. Portion of a transverse section of a young microsporange showing archesporium, two of its cells have already divided periclinally, while the other is in process of division. × 890.

Fig. 23. Showing primary parietal cells divided and inner sporogenous cells also dividing to give rise to a mass of microspore mother cells. × 890.

Fig. 24. Microspore mother cells in process of division. × 1060.

Fig. 25. Microspore mother cells in telophase stage of their heterotypic division. × 1060.

Fig. 26. Binucleate tapetal cells. × 1060.

Fig. 27. Young tetrad (microspore). × 1060.

Fig. 28. Showing microspore germinated in 1 per cent sugar solution. × 490.

PLATE III

Fig. 29. Portion of transverse section of young ovary wall showing a vascular bundle and its homogeneous ground tissue. × 235.

Fig. 30. Longitudinal section of a young pericarp showing beginnings of differentiation. × 235.

Fig. 31. Longitudinal section of older pericarp to show further differentiation. × 235.

Fig. 32. Portion of a longitudinal section of a nearly mature but green pericarp at its outer portion showing outer region of small compressed cells, a vascular bundle and large central parenchyma. × 53.

Fig. 33. Portion of longitudinal section from fig. 32 showing its inner epidermis and surrounding hypodermal tissue. × 112.

Fig. 34. Portion of a transverse section a nearly mature pericarp showing its outer region and part of the middle enlarged parenchyma. × 53.

Fig. 35. Portion of transverse section from fig. 34 showing its inner region and part of the middle enlarged parenchyma. × 112.

Fig. 36. Portion of a longitudinal section of a young seed coat. × 235.

Fig. 37. Portion of a longitudinal section of mature seed coat. × 235.

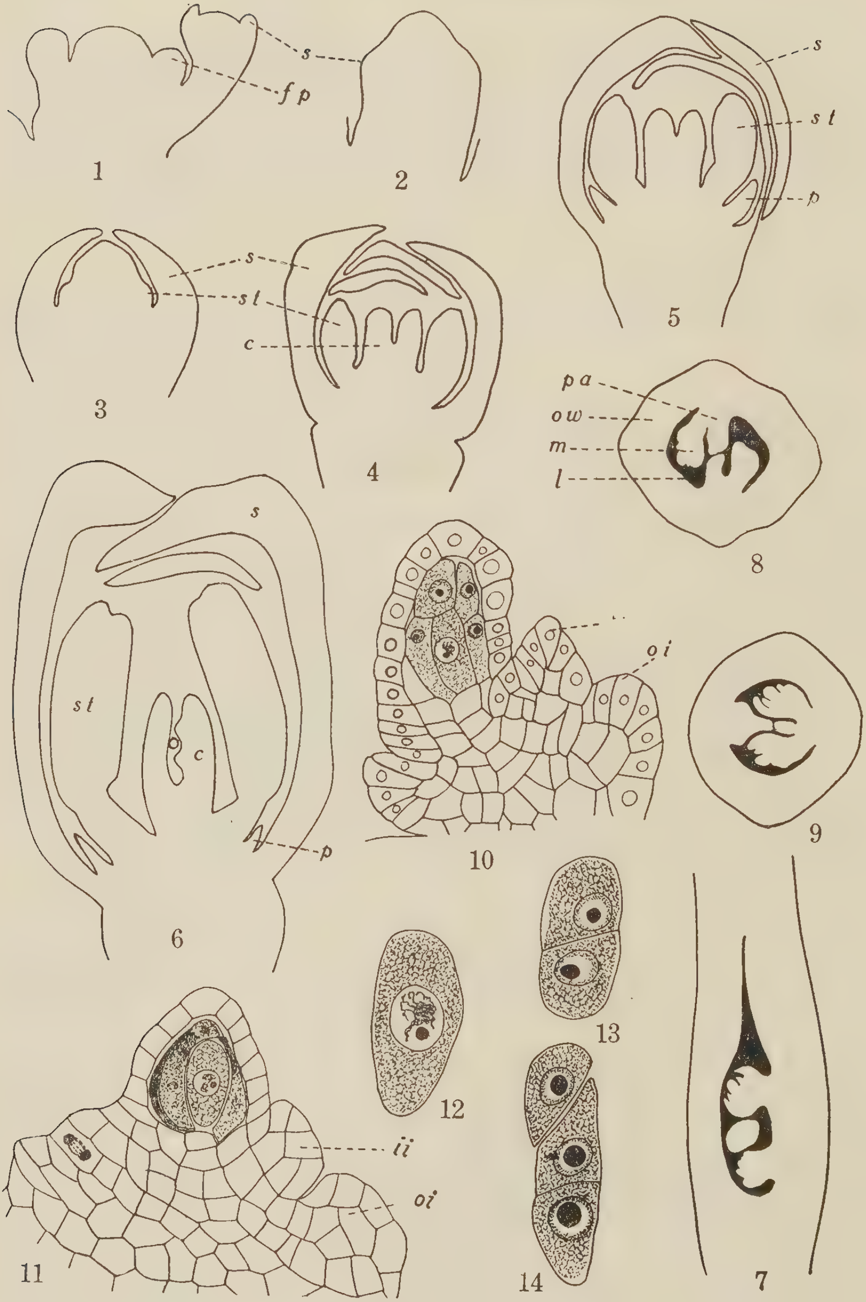
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Plate 1

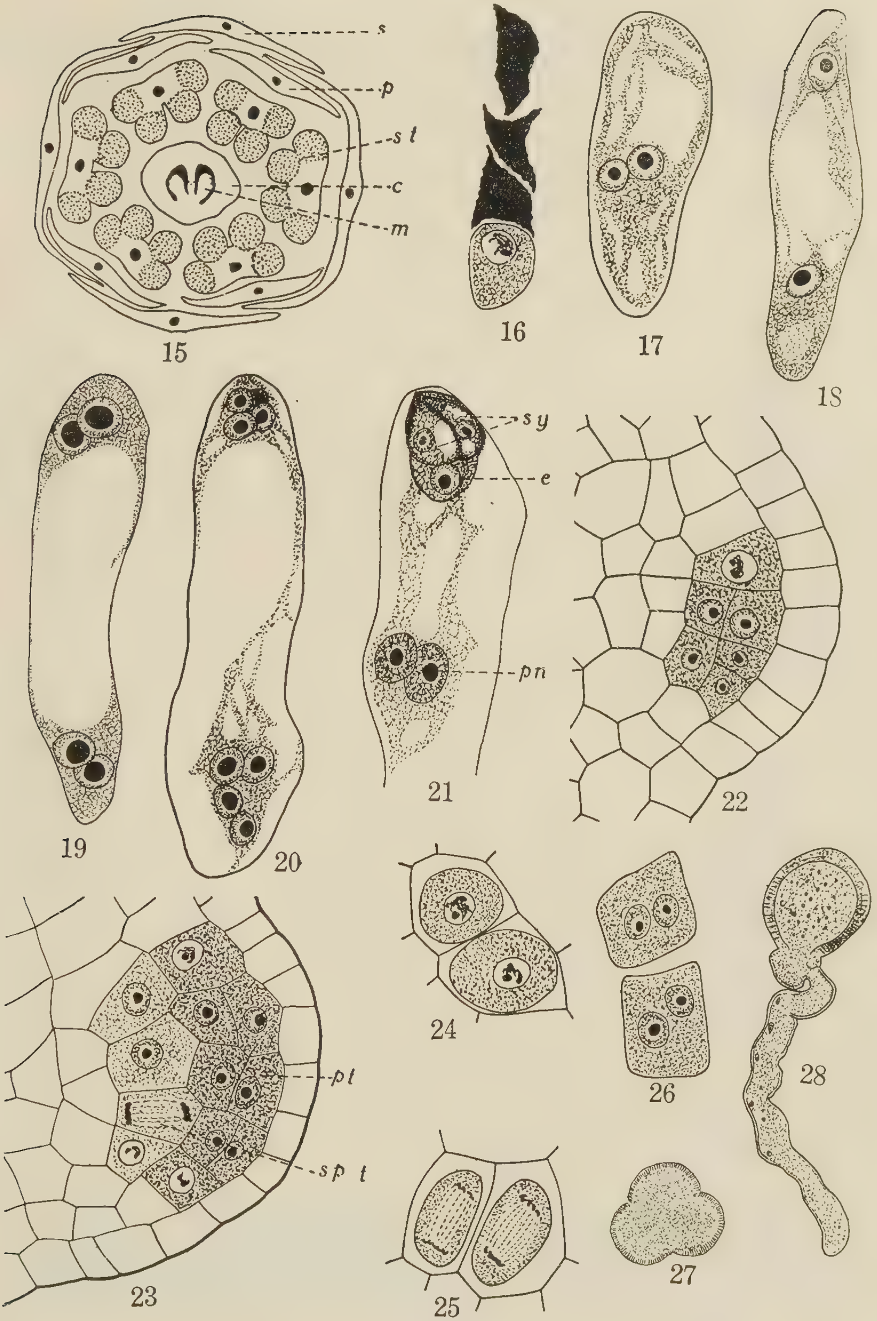
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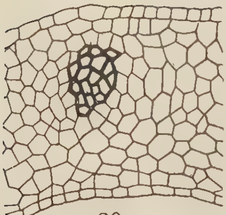
Plate 2



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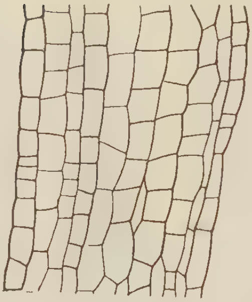

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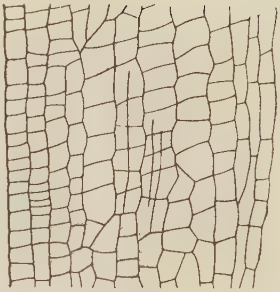

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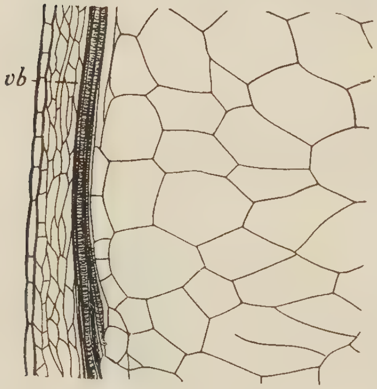

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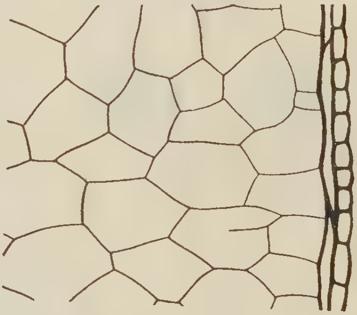

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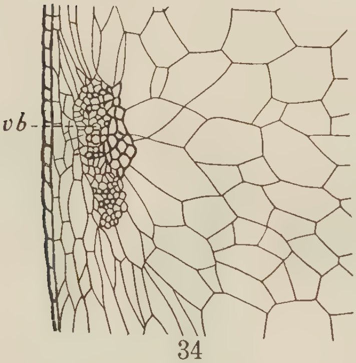

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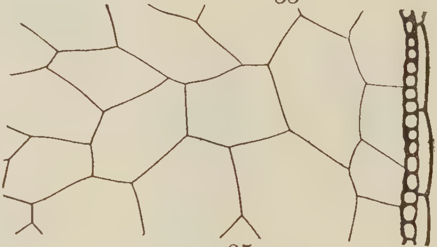

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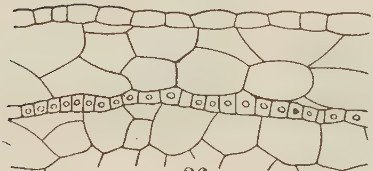

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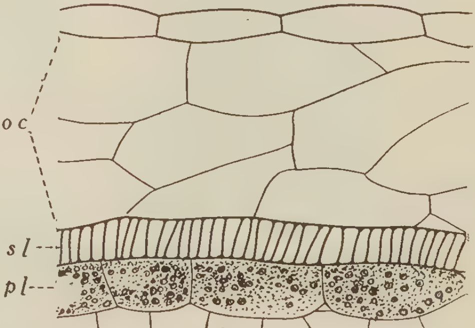

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PLATE 3

PROTEIN SUPPLEMENTS IN POULTRY RATIONS: VIII. STUDIES TO DETERMINE THE OPTIMUM AMOUNT OF MUNGO THAT MAY BE USED IN A NORMAL RATION FOR GROWING CHICKS[1]

FELINO L. RODRIGUEZ

WITH ONE CHART

In his studies on the influence of mungo meal[2] in rations for growing chicks, Adan (1935) reported that the use of this product as the sole protein supplement with rice bran, copra meal and corn meal, did not produce satisfactory results. But mungo meal might profitably be combined with shrimp meal, and, if so, the most satisfactory proportion should be determined. To answer these two questions, a study was conducted and the results obtained are reported in this paper.

Review of literature

Available literature reveals that mungo is a very promising ingredient in poultry rations, for, according to Tuason and Fronda (1924), a mixture of corn meal and mungo meal was the most palatable among the several feeds they tested, including fish meal and shrimp meal. They also reported that mungo can be used fairly well either singly or mixed.

Cruz (1918) in his studies on the effect of certain Philippine feeds on growth and production of eggs and meat of poultry, reported that the mungo-fed lot gave the highest total production of eggs. When mungo was used as feed for growing chicks, Cruz also reported that the mixed ration was the best for it produced the heaviest average weight per chick per week. When it was used for fattening hens, this author reported that a combination of mungo, corn, and rice gave the highest average growth per hen. For fattening capons, Rodriguez (1923) reported that the addition of mungo to the basal ration consisting of 15 parts of corn meal and 10 parts of rice bran by weight, produced the best results, while the addition of copra meal alone to the basal mixture was third. Adan (1934), however, reported that the addition of mungo meal alone as supplement to rice bran, copra meal, and corn meal for growing chickens is not advisable.

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[1] Thesis presented for graduation, 1935, with the degree of Bachelor of Science in Agriculture from the College of Agriculture, No. 507; Experiment Station contribution No. 1143. Prepared in the poultry division, Department of Animal Husbandry, under the direction of Dr. F. M. Fronda.

[2] Mungo meal, as used in this article, is the ground seed of mungo (*Phaseolus aureus* Roxb.)

OBJECT AND TIME AND PLACE OF THE STUDY

The object of this study was to determine the best combination of shrimp meal and mungo meal in rations for growing chicks.

The experiments were conducted in the Poultry Division, Department of Animal Husbandry, College of Agriculture, University of the Philippines, Laguna, from May 23, 1934 to February 28, 1935.

MATERIALS AND METHODS

A total of 384 Los Baños Cantonese chicks were used in this experiment. These chicks were obtained from three hatches. The chicks from each hatch were divided into six lots. The first hatch had 25 chicks to the lot; the second, 20, and the third, 19, making a total of 64 chicks in each lot in the three hatches.

The basal mixture used in this experiment consisted of fine grade rice bran and yellow corn meal in the proportion of 3 to 1. In addition to this mixture, shrimp meal and mungo meal were used as supplements, singly and in combination in the proportion shown in the following table:

INGREDIENTS	LOT I	LOT II	LOT III	LOT IV	LOT V	LOT VI
	parts	*parts*	*parts*	*parts*	*parts*	*parts*
Rice bran	56.25	56.25	56.25	56.25	56.25	56.25
Corn meal	18.75	18.75	18.75	18.75	18.75	18.75
Shrimp meal .	25.00	20.00	15.00	10.00	5.00	0.00
Mungo meal ..	0.00	5.00	10.00	15.00	20.00	25.00

Feeding, care, and management. The feeds were given to the chicks in the form of dry mash. To avoid over-feeding for the first few days after hatching, the chicks were given only a small amount of feed. Later, the chicks were allowed free access to feeds at all times of the day.

The chicks were reared in fireless brooders. During the first four weeks, they were kept in the laboratory rearing quarters but later they were transferred to open rearing yards which were about three meters wide and four meters long. Abundant green feed, shell, grit, and fresh water were supplied to the chicks at all times.

Records. During this experiment, close observations on the growth and mortality of the chicks in the different lots were made and recorded.

RESULTS AND DISCUSSIONS

Growth of chicks. The average rate of growth of chicks in the different lots of the three trials observed are presented in table 1 and graphically shown in chart 1. It may be noted from the table that the mean weights of one-day old chicks in the six lots studied show no significant differences. During the first four weeks, the rate of growth of the chicks in all the lots was about the same, except in lots V and VI where lower rates of growth than in the other lots were noted after the second week. It may be noted further from this table, that the gradual increase in weight of the chicks in lots I, II, III and IV does not vary much, but in the chicks in lots V and VI, there was a decidedly slower rate of growth.

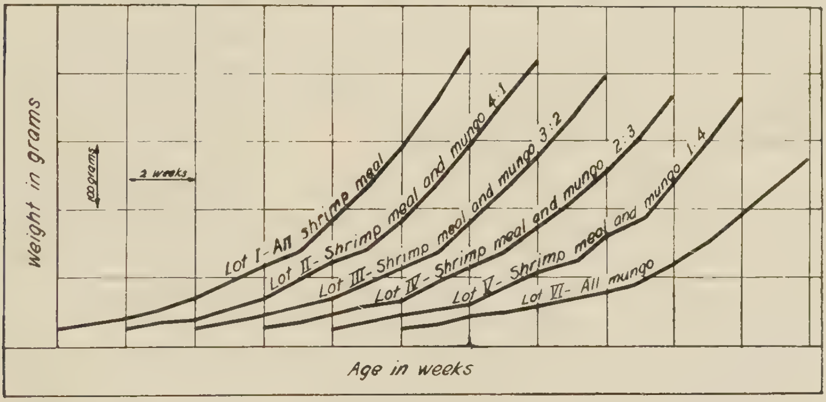

Chart 1.—Average of growth of the chicks in the different lots.

At the age of twelve weeks the mean weights of the chicks were as follows: Lot I, 432.2 ± 10.708 grams; lot II, 419.9 ± 10.613 grams; lot III, 398.9 ± 10.489 grams; lot IV, 367.2 ± 11.643 grams; lot V, 365.8 ± 16.121 grams; and lot VI, 272.9 ± 12.679 grams. Lots I, II, and III showed no significant differences. Lot I, however, was significantly better than lots IV, V and VI. No significant difference was obtained when lot II was compared with lot III, but lot II was significantly better than lots IV, V, and VI. Lots IV and V when compared showed no significant difference in their mean weights, but there was a significant difference when lot IV was compared with lot VI, lot IV being the better of the two. A significant difference was obtained between lot V and lot VI, lot V being the better one.

The variation in the mean final weights was probably due to the effects of the different combinations of mungo meal and shrimp meal in various proportions. These results corroborate the observation of Adan (1934). The superiority of lot I to the other lots may be explained by the amount and kind of proteins supplied by the rations. In this lot, over 60 per cent of the total proteins is supplied in the form of animal proteins (shrimp) which is of better quality than vegetable proteins.

Basing upon the weight of the chicks at the age of twelve weeks, it appears that as much as 40 per cent of the shrimp meal in the ration for growing chicks may be replaced with mungo with satisfactory results. The best ration used in this study contained 25 per cent shrimp meal. The combination of 20 parts shrimp meal and 5 parts mungo meal and 15 parts shrimp meal and 10 parts mungo meal may be considered satisfactory.

Feeds consumed. The total amounts of feeds charged to the different lots are given in table 2. The price per kilogram of the different rations in the various lots was almost the same, because the price of mungo was almost as high as that of shrimp meal per unit of weight (see table 2). It may be seen from these figures that lot I produced the highest gain among the lots studied; and lot II, the second highest.

Assuming that lot I (25 shrimp meal no mungo meal) as 100 per cent efficient, it was found that lot II (20 shrimp meal-5 mungo meal) was 97.15 per cent; lot III (15 shrimp meal-10 mungo meal), 92.30 per cent; lot IV (10 shrimp meal-15 mungo meal), 84.96 per cent; lot V (5 shrimp meal-20 mungo meal), 84.64 per cent; while lot VI (no shrimp meal-25 mungo meal) was only 63.14 per cent efficient.

Effects of feeds on the mortality of chicks. In all the three trials, it was found that the mortality of the chicks in lots V and VI was very much higher than in lots I, II, III and IV (see table 3). In the third set, the mortality of the chicks was high in all the lots. The cause of this high mortality may be the rainy weather that prevailed when this hatch was removed from the incubator. For almost one month the weather conditions were unfavorable for the normal development of chicks. Even in this set, lots V and VI had higher mortality than the other lots. There was an evident tendency, therefore, that as the amount of mungo meal added to the ration was increased the mortality of the chicks increased also.

The percentage of mortality found in this experiment was rather high in the lots fed with mungo meal. Adan (1934) reported 56.2 per cent mortality in the lots fed with mash containing 20 per cent of mungo meal. That mungo contains not only a lower percentage of proteins than shrimp meal but also proteins of poorer quality may be the cause of this high percentage of mortality. As far as mortality is concerned, as much as 60 per cent of the shrimp meal may be replaced with mungo meal to produce fairly satisfactory results.

SUMMARY AND CONCLUSIONS

The results of using a combination of shrimp meal and mungo meal in rations for growing chicks may be summarized as follows:

1. Shrimp meal, when used as the sole protein supplement for growing chicks at 25 per cent of the total mash mixture, was decidedly superior to any mixture wherein mungo meal was used as a partial or total substitute.
2. Indications show that 20 to 40 per cent of the shrimp meal may be replaced with an equal amount of mungo meal in the mixture and may produce fairly satisfactory results.
3. When the shrimp meal was completely replaced with mungo meal, the mortality of the chicks was very high, and the chicks produced were very small.
4. In localities where shrimp meal is scarce and mungo is grown abundantly, as much as 40 per cent of the latter may be used to replace an equal amount of the former.
5. If mungo costs as much as shrimp meal per unit of weight, the use of mungo in the mash mixture is not advisable.
6. Considering the mean final weight of the chicks in the different lots as the criterion in comparing the efficiency of the different mash mixtures, and taking lot I as 100 per cent, lot II was 97.15 per cent, lot III, 92.30 per cent, lot IV, 84.96 per cent, lot V, 84.64 per cent and lot VI, only 63.14 per cent.

TABLE 1

Mean weekly weights of the chicks in the different lots for twelve weeks

AGE	LOT I (0 PER CENT MUNGO MEAL)		LOT II (5 PER CENT MUNGO MEAL)		LOT III (10 PER CENT MUNGO MEAL)	
	Number of chicks	Mean weight	Number of chicks	Mean weight	Number of chicks	Mean weight
		grams		*grams*		*grams*
1 day	64	27.4 ± 0.212	64	27.3 ± 0.203	64	27.8 ± 0.204
1 week	59	34.0 ± 0.377	61	35.1 ± 0.320	60	34.6 ± 0.477
2 weeks	51	43.6 ± 0.181	55	44.0 ± 0.533	54	44.4 ± 0.665
3 weeks	49	53.7 ± 0.983	53	56.1 ± 0.983	48	53.8 ± 0.715
4 weeks	47	71.8 ± 1.393	42	70.0 ± 1.498	45	70.2 ± 1.410
5 weeks	45	97.2 ± 2.982	40	99.0 ± 2.606	44	93.7 ± 2.610
6 weeks	45	119.4 ± 3.115	38	124.7 ± 3.396	42	116.5 ± 3.087
7 weeks	45	139.7 ± 4.256	37	143.6 ± 3.082	41	137.5 ± 3.407
8 weeks	42	184.6 ± 5.017	35	185.6 ± 4.337	38	181.6 ± 4.816
9 weeks	41	236.8 ± 6.987	33	236.8 ± 5.801	37	231.3 ± 5.665
10 weeks	41	290.7 ± 6.700	33	291.4 ± 8.245	36	277.2 ± 8.103
11 weeks	41	363.9 ± 8.845	33	359.3 ± 9.801	36	337.2 ± 10.504
12 weeks	41	432.2 ± 10.708	33	419.9 ± 10.613	36	398.9 ± 10.489

TABLE 1 (Continued)

AGE	LOT IV (15 PER CENT MUNGO MEAL)		LOT V (20 PER CENT MUNGO MEAL)		LOT VI (25 PER CENT MUNGO MEAL)	
	Number of chicks	Mean weight	Number of chicks	Mean weight	Number of chicks	Mean weight
		grams		*grams*		*grams*
1 day	64	28.5 ± 0.181	64	27.6 ± 0.210	64	26.8 ± 0.171
1 week	59	36.8 ± 1.026	60	34.5 ± 0.184	56	34.1 ± 0.263
2 weeks	57	46.9 ± 0.644	55	42.8 ± 0.617	52	42.3 ± 0.358
3 weeks	55	57.5 ± 0.937	48	51.6 ± 1.143	48	49.9 ± 0.640
4 weeks	54	58.1 ± 1.158	47	61.9 ± 1.480	45	56.8 ± 1.030
5 weeks	54	92.7 ± 2.333	45	86.8 ± 3.122	43	69.6 ± 2.049
6 weeks	52	114.9 ± 3.463	42	108.8 ± 3.852	39	79.3 ± 2.952
7 weeks	48	133.7 ± 4.497	37	123.1 ± 5.220	32	93.5 ± 3.308
8 weeks	45	176.3 ± 6.366	34	160.5 ± 6.994	30	116.5 ± 4.651
9 weeks	42	221.4 ± 10.011	32	188.6 ± 8.412	26	151.3 ± 5.885
10 weeks	40	267.5 ± 10.186	30	237.8 ± 10.545	21	194.8 ± 8.304
11 weeks	39	311.0 ± 10.480	30	299.2 ± 14.266	21	239.5 ± 12.416
12 weeks	39	367.2 ± 11.643	30	365.8 ± 16.121	21	272.9 ± 12.679

TABLE 2

Amount and cost of feeds charged to the different lots per 100 birds and the returns above cost of feeds

ITEMS	LOT NUMBER					
	I	II	III	IV	V	VI
Number of chicks brooded	64	64	64	64	64	64
Number of chicks weaned	41	33	36	39	30	21
Total amount of feed consumed (kgm.)	82.0	75.9	90.0	93.6	78.0	58.8
Amount of feed consumed per 100 birds (kgm.)	200.0	230.0	250.0	240.0	260.0	280.0
Cost per kilogram feed (cts.)[a]	0.068	0.068	0.067	0.067	0.067	0.066
Cost of feed consumed per 100 birds (pesos)	13.60	15.64	16.75	16.08	17.42	18.48
Total weight of birds per 100 (kgm.)	43.22	41.99	39.89	36.72	36.58	27.29
Total value per 100 birds @ ₱0.60 a kilogram (pesos)	25.93	25.19	23.93	22.03	21.95	16.37
Amount of feed required to make a kilogram weight (kgm.)	4.6	5.5	6.3	6.5	7.1	10.3
Cost of feed required to make a kilogram weight (cts.)	0.31	0.37	0.42	0.44	0.48	0.68
Returns above cost of feeds per 100 birds (pesos)	12.33	9.55	7.18	5.95	4.53	—2.11
Efficiency of the feeds based on the weight of the chicks at 12 weeks (per cent)	100.00	97.15	92.30	84.96	84.64	63.14

[a] The cost per kilogram of the feeds used were:

Rice bran	₱0.028
Corn	0.042
Shrimp	0.179
Mungo	0.170

TABLE 3

Percentage of mortality of the chicks in the different lots at the end of the experiment

LOT NO.	SETS			AVERAGE
	1st	2nd	3rd	
	per cent	*per cent*	*per cent*	
I	30.00	32.00	47.36	36.45 ± 3.699
II	40.00	40.00	68.42	49.47 ± 6.390
III	35.00	36.00	63.15	44.71 ± 6.220
IV	35.00	40.00	42.10	39.03 ± 1.420
V	40.00	40.00	84.21	54.73 ± 9.930
VI	75.00	48.00	84.21	69.07 ± 8.695

COLLEGE AND ALUMNI NOTES

Hon. Sergio Osmeña, vice president of the Philippine Commonwealth, secretary of public instruction, and chairman of the board of regents, University of the Philippines, was the guest of honor at the Loyalty Day celebration of the College on October 10. In an address at the Baker Memorial Hall, he stressed the need for future development of the Philippines as a land of small farmers. "The small farmer," he points out, "who owns his land and the house in which he lives is the primary producer; he supports the social order; he fulfills loyally in times of emergency his obligations to the country. Hence, a policy that would assure a parcel of land and a house to every Filipino would be the best means of guaranteeing the security of the state and the preservation of the race."

The Loyalty Day parade and military review was held in the morning, despite pouring rain. Among the floats that took part, those of the following won prizes: *first prize,* Department of Agronomy; *second prize,* a tie between the Departments of Animal Husbandry and Agricultural Education; *honorable mention,* Los Baños Economic Garden (Bureau of Plant Industry).

The Citrus Growers' Association, a society composed of agricultural students from Batangas province, held its annual program and dance in one of the bathing resorts at Los Baños on September 19.

Hon. José E. Romero, floor leader of the National Assembly, was the guest of honor of the Soil Tillers, an association of Visayan students, at its annual ball in the seniors' social garden, College campus, on September 12.

The Society for the Advancement of Research held its tenth initiation exercises on September 26, in the College auditorium. The names of the three undergraduate seniors who were inducted as associate members are listed in the September issue of this paper. Director Arthur F. Fischer, of the Bureau of Forestry, was the guest of honor.

At the faculty conference held in the College library on September 29, the following papers were read: Prof. Cristino Jamias, of the English Department, College of Liberal Arts, on extracurricular activities; and Prof. Bernabe Africa, of the Department of Political Science, of the same college, on the U. P. Information Service.

The following papers were presented at the monthly meeting of the Los Baños Biological Club on September 24: Dr. V. Villegas, Mr. L. A. Ynalvez, and Mr. A. Elepaño—"A comparative study of the amount of feces voided by Philippine Nellore cattle and the fertilizing constituents contained therein;" Dr. L. B. Uichanco—"A report on a recent trip to Mindanao;" Dr. J. B. Juliano and Dr. Eduardo Quisumbing—"Floral mechanism in *Sterculia apetala* (Jacq.) Karsten."

In a speech at the annual meeting of the University of the Philippines Alumni Association, Laguna Chapter, on October 10, at the Molawin Hall, President Jorge Bocobo dwelt at length on the significant rôle of provincial chapters in promoting closer relation between the University and the alumni scattered all over the islands. He mentioned in passing that the College of Agriculture is the most active research unit of his institution, its research projects representing over 50 per cent of the University's total.

In the business meeting that followed, it was decided to change the name of the chapter from Laguna Chapter No. 1 to Laguna Chapter. The officers for the previous term were reëlected; namely, Dr. N. B. Mendiola, president; Dr. L. B. Uichanco, vice-president; Dr. F. M. Fronda, secretary-treasurer; and Dean B. M. Gonzalez and Prof. Doroteo Soriano, directors. Dr. Patrocinio Valenzuela represented the mother chapter of the Association.

Mr. Christian Reimers, superintendent of the Central Luzon Agricultural School, Muñoz, Nueva Ecija, was a campus visitor on September 21. He was accompanied by President Bocobo.

At a meeting of the College of Agriculture faculty on October 12, it was approved to recommend to the University Council the graduation of the following candidates: *Bachelor of Science in Agriculture*—Marcos J. Aldama, B.Agr., Telesforo L. Ayson, Teofilo C. Briones,

Arsenio L. Castillo, Leandro V. Castillo, Primo R. Castro, Dominador E. Eamilao, Bonifacio A. Espejo, B.Agr., Santos S. Garcia, José L. Golez, Francisco Gomez, Kan Jalavicharana, Cornelio Macabasco, Archibaldo Madrigal, Leon L. Mencias, Restituto B. Realeza. *Bachelor of Science in Sugar Technology*—Teodoro G. Megia. *Certificate in Agricultural Education*—Onofre F. Martin, B.S.Agr.

IN MEMORIAM

ESTEBAN GONZALEZ COLLADO, B.Agr., 1919, B.S.Agr., 1922, M.S., 1923, University of the Philippines. Born July 31, 1892, in Ballesteros, Cagayan Province. Entered the College of Agriculture, June 16, 1913. Assistant in agricultural chemistry, 1919 to 1923; instructor since 1923. Assistant manager of the Molawin Hall (students' mess) since his undergraduate days. Sergeant, Philippine National Guard, quartermaster corps, at Camp Claudio, 1918. Assistant dietitian, Filipino Olympic team at Tokyo, 1930. Died at Los Baños, Laguna Province, October 3, 1936.

PROSPECTS OF THE PHILIPPINE FOREIGN TRADE[1]

PABLO N. MABBUN
Of the Department of Agricultural Economics

WITH ONE CHART

The outlook for the overseas trade of the Philippines may be studied from its performance in the past. During the early years of the Spanish régime, 1566-1830, Spain had virtual monopoly of the overseas trade of the Islands. The volume of this trade did not exceed 3 million pesos annually, including the ₱500,000 annual subsidy coming from Mexico.[2] Later, after Spain opened the ports of the colony in 1834,[3] the Philippines developed a substantial trade with Great Britain, China, Spain, the United States, British East Indies, France, Australia, Japan, Belgium, the Netherlands, Italy, and the Dutch East Indies. The volume of this trade with each of these countries was in the descending order as they are here listed. The annual average volume of this trade toward the end of the Spanish régime, 1891-1895, amounted to ₱69,585,000, of which ₱39,000,000 represented the value of the exports and ₱30,500,000, the imports. The annual balance of trade favorable to the Islands amounted to ₱8,500,000. The exports were chiefly agricultural products and the imports were largely manufactured goods, characteristics of the overseas trade of the Philippines which still persist. (See table 1).

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[1] General contribution from the College of Agriculture No. 536.

[2] There was some trading with China, India and the East Indies during this period, but goods exported from the Islands to these countries and those imported into the colony from them had to be carried on Chinese junks, since the state galleons were not allowed to make stop-overs at the ports of these Oriental countries on their trips to and from Mexico. This and other restrictions curtailed the progress of the overseas trade of the colony. See Tomas de Comyn, "State of the Philippines in 1810", in *The Former Philippines Through Foreign Eyes,* 1917, pp. 379-380; also John Foreman, *The Philippines and Its Dependencies,* 1899, pp. 271, 282.

[3] The granting of a charter to the *Real Compañia de Filipinas* in 1875 opened the port of Manila to other countries, but the privileges conceded to this company by the King made it impossible for foreign merchants to do business in that port. The *Real Cedula* of 28th May, 1830, withdrew the privileges heretofore enjoyed by this company, but foreign merchants' influence in the overseas trade of the Islands was not felt until 1834. See Tomas de Comyn, "State of the Philippines in 1810," in *The Former Philippines Through Foreign Eyes,* p. 405; also John Foreman, *The Philippines and Its Dependencies,* pp. 285, 287.

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The Spanish tariff, which should have favored Spain in the overseas trade of the colony, did not make that country play the leading rôle in this trade. In fact, Spain occupied only third place in the relative importance of the principal countries trading with the Islands, Great Britain being the first and China the second. The reasons were: (1) Spain could not compete with Great Britain in the overseas carrying trade of the colony; and (2) the Spanish market could not absorb the bulk of the products the colony wanted to sell to pay for its imports. Moreover, Spain did not have manufactured goods in sufficient quantity and variety to meet the demands of the colony. The Spanish government, however, did not discourage this tendency, because it looked upon the overseas trade of the Islands mainly to raise revenue for the King and to defray part of the expenses of the colonial government. Hence, the imposition of duties on both the exports and imports of the colony.

Upon taking possession of the Philippines in 1899 the United States desired, among other things, to foster the economic development of the Islands and raise the standard of living of the Filipinos. Incidentally, it expected to open opportunities in the Orient for American exports. Thus, between 1902 and 1909, the United States admitted Philippine products into the American market under a tariff preference of 25 to 50 per cent of the regular duties imposed on similar products from foreign countries by the Dingley Act of 1897.[4] American goods and ships, however, received the same treatment in the Islands as those of Spain in obedience to the Treaty of Paris of 1899.

During the period from 1899 to 1909, the annual volume of overseas trade of the Islands amounted to about 116 million pesos on an average. Of this amount, about 58.0 million pesos represented the value of exports and about 57.8 million pesos that of imports, showing an annual balance of ₱200,000 favorable to the Islands. (See table 2).

But the bulk of this trade was still with foreign countries, the United States taking only 34.4 per cent, in value, of the exports and furnishing but 14.7 per cent, in value, of the imports. Foreign countries, also, still dominated the overseas carrying trade of the Philippines, Great Britain carrying 65 per cent of the total tonnage of cargoes, compared with 12 per cent carried by Spanish, 10 per cent by German, and only 3 per cent by American vessels.

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[4] The Act of Congress of March 8, 1902, granted a reduction of 25 per cent of the regular Dingley rates in favor of Philippine products entering the United States. The Tariff Act of March 3, 1905 increased this tariff preference to 50 per cent of the Dingley rates, but only in favor of Philippine manufactured tobacco entering the American market.

Then, the duty-free trade relationship was inaugurated between America and the Philippines by the Payne-Aldrich Tariff of August 5, 1909.[5] This trade relationship stimulated the production of export commodities in the Islands. The expansion of the export trade of the Islands consequently increased the purchasing power and raised the standard of living of the Filipino people. Goods from abroad came into the Philippines in increasing quantities and varieties. Since Phlippine exports were attracted by the more profitable American market, consequently, the Islands purchased American goods in correspondingly increasing amounts.

During the period from 1910 to 1920, the annual volume of the overseas trade of the Islands averaged about 299 million pesos, 155.6 million pesos of which represented the value of exports and 143.4 million pesos, the imports. The annual balance of trade favorable to the Islands amounted to 12.2 million pesos. The United States took 55.5 per cent, in value, of the exports and furnished 45.5 per cent, in value, of the imports; the balance of the trade was carried on with foreign countries.

Between 1921 and 1931, the United States strengthened the protection enjoyed by Philippine products in the American market.[6] This increased the profitableness of the American market and consequently intensified the dependence of the Philippine overseas trade upon that market. During this period, the annual volume of the overseas trade of the Islands averaged about 488.8 million pesos, 261.4 million pesos of which represented the value of exports and 227.4 million pesos the imports. The annual balance of trade favorable to the Philippines averaged 34 million pesos. The United States took 73.8 per cent, in value, of the exports and furnished 60.8 per cent, in value, of the imports. (See table 2).

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[5] The Underwood Tariff of Octboer 3, 1913, made this trade relationship legally mutual, although the limitations placed on the amounts of Philippine sugar and tobacco products entering the United States free of duty by the Payne-Aldrich Act were never reached by actual shipments of these products to the American market during the enforcement of the law.

[6] The Emergency Tariff of 1921 increased the duty on sugar coming into the United States from foreign countries to 2 cents per pound. The Customs Revenue Act of 1922 further increased this duty to 2.2 cents per pound, imposed duties of 2 cents per pound on coconut oil and 3.5 cents per pound on desiccated coconut from foreign countries. The Hawley-Smoot Tariff of 1930 again raised the duty on sugar to 2.5 cents per pound and imposed a duty of 2.5 cents per pound on cordage from foreign countries.

In 1934, the dominant position of the United States in the overseas trade of the Islands was further strengthened to 83 per cent, in value, of the exports and 65 per cent, in value, of the imports.

Under the duty-free trade relationship, the United States also took the leading position in the overseas carrying trade of the Philippines. During the period from 1922 to 1933, American ships, carried 35 per cent of the total tonnage of Philippine overseas cargoes, compared with 25 per cent carried by British, 19 per cent by Japanese, 6 per cent by Norwegian, 5 per cent by Spanish, 4 per cent each by Dutch and German, and only 3 per cent by Philippine vessels.

During the twenty-six years of this duty-free trade, 1909 to 1934, the Philippines imported from the United States goods valued at ₱2,690,192,000, or a per capita importation of ₱206.94, compared with American purchases of Philippine products amounting to ₱3,611,344,000, or a per capita of only ₱20.89.[7] On the basis of per capita purchase, therefore, the Philippines has been about ten times a better market for American exports than the United States has been for Philippine products during this period of reciprocal duty-free trade. Incidentally, during its term in the Islands, the United States has developed a substantial export trade with China, Japan, and the East Indies, amounting to about 800 million pesos during the period from 1925 to 1929.[8]

OUTLOOK FOR PHILIPPINE OVERSEAS TRADE

The large dependence of the overseas trade of the Islands upon the American market is significant as a prospective for the probable future trend of this trade. During the period from 1924 to 1934, the annual average value of the exports of the Islands which are largely dependent upon the American market, including sugar, coconut oil, desiccated coconut, cigars, embroideries, and cordage, amounted to ₱146,792,034, or 75.36 per cent of the total annual average value of the export trade of the Philippines during this period. (See table 3). This dependence presents the following problems:

1. Should the producers of these exports fail to reduce their cost of production and should the prices of such exports remain at their present levels, their exportation to the United States will probably

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[7] Based on a population of 13 millions for the Philippines and 125 millions for the United States.

[8] These markets were developed despite the failure of America to realize its expectation to develop the ports of the Philippines as distributing centers for American exports to Oriental countries. The amount of American products reexported from the Islands to various Asiatic points never exceeded 4.4 per cent, in value, of all American exports to the Islands from 1910-1932.

cease, because they cannot be profitably sold in that country. Neither can they be disposed of competitively in the open markets of the world, because their cost of production is relatively high. There would, consequently, be a probable reduction in the export trade of the Islands by about 75 per cent of its present volume. If past experience may be used as a basis, the volume of the import trade of this country with the United States would be reduced by a corresponding amount, since the import trade of the Islands has closely followed the behavior of their export trade during the whole period of the American Administration under review, 1899 to 1934. (See chart 1).

2. Failure to sell export products abroad would result in the contraction of their production to the size of the demand for them in the local market. This would force out of work a number of laborers and employees now engaged in the enterprises producing these products. Incidentally, the unemployment created would affect the purchasing power of the domestic consumers, thereby weakening the demand for locally produced goods. There would be a smaller circulation of money in the country and a general decline in the standard of living of the people.

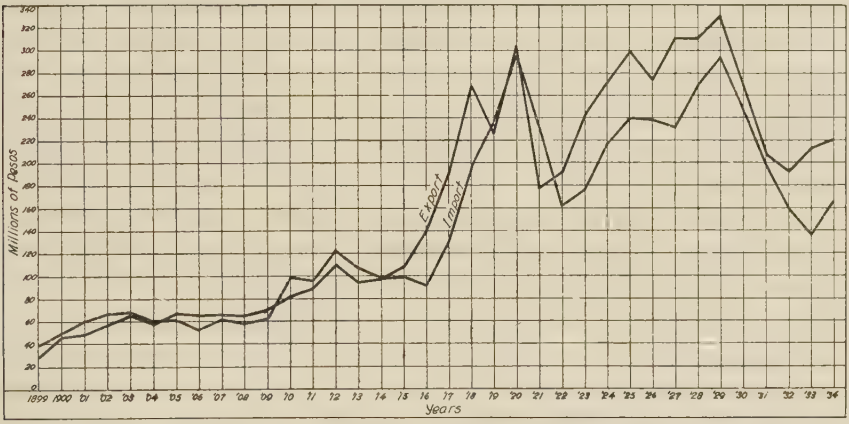

Chart 1. Trend of Philippine overseas trade, 1899 to 1934.

3. The decrease in government revenue owing to the decrease in customs collection will oblige the Government to provide new ways of increasing governmental income. There would be an increase in the present rate of taxation, a thing which would be difficult of enforcement, in view of the already impoverished condition of the people.

To prevent this situation, or at least to minimize its weight on the economic life of the people, the following remedies are indicated:

1. *Reduction of the cost of production of export products.* This is perhaps the most logical step that should be taken, if the producers of the export products want to put their enterprises on equal footing with those of their competitors. No general method that will be practical for all the varied enterprises producing these commodities can be prescribed, but in general this task would require: (a) Increase in the efficiency of labor. This will likely be followed by demands for increase in wages, for labor cannot increase its effectiveness if wages paid to workers are on the mere subsistence level. The increase in the outlay for wages will ultimately result in a lower cost per unit of product turned out by efficient laborers. This has been shown by the experiences of the Ford Motor Company and the Japanese textile plants. (b) Constant research to make possible the employment of the best and most economical combination of the factors of production. (c) The utilization of by-products in order to increase the output of the plant, thereby decreasing the expenditure per unit of output.

2. *Improving the trade in those products which constitute the mainstay of our export trade.* Abacá, copra, leaf tobacco and lumber, because of their nature and favored position in the world's markets, may be called the mainstay of the overseas trade of the Islands. The Philippines has a virtual monopoly of the world supply of abacá, notwithstanding the claim of Sumatra and Java to the contrary. Reducing the cost of production, improving the quality of the fiber, manufacturing articles from the fiber, and advertising its new uses will increase the volume of trade in this product considerably. Moreover, Japan will likely continue to dominate the Philippine trade in this product, in view of the growing influence of the Japanese capital invested in the Japanese corporations now producing abacá in Davao.

Tobacco leaf is still sold in large quantities to European countries. In fact, the bulk of the leaf-tobacco exports still finds its way to the old mother country, Spain, undoubtedly because of the influence of the Spanish capital invested in the Spanish corporations, such as the Compañia Tabacalera, La Insular and others, which dominate the local, as well as the overseas, trade in this product in the Islands.

Copra and lumber are on the free list of American exports. These products are also still being exported to various markets. They will, therefore, continue to be important items in the export trade of this country. Constant reduction of their cost of production and improvement in their quality will likely increase the volume of the trade in these products.

Shell products and hats have a distinct demand in the American market. So that, regardless of future tariff restrictions, these products will continue to find a market in the United States.

Besides the products first named, gold exports show a tendency of becoming one of the leading items of the future export trade of the Philippines.

3. *Development of foreign outlets for our exports.* The Government cannot begin too early on this task. Once the permission of the United States is obtained, the Government should establish trade agencies in commercial centers of the world where Philippine products may appear to have a bright future. Since the financial condition of the Government will make any progress slow, it is important that the necessary steps be taken as soon as it is legally possible. Delay in its realization may mean a serious setback in the export trade of this country in the future and consequently a hard blow to the standard of life of its people.

4. *Reciprocal trade treaty with the United States.* The Tydings-McDuffie law authorizes the President of the United States to convene representatives of the American and Philippine Governments to determine the future trade relations between the two countries. The biggest hope of Philippine overseas trade lies in the establishment by this trade conference of a reciprocal trade relationship between America and an independent Philippines. There are, however, certain forces that will likely favor and others that will likely oppose such a trade arrangement. Besides the benefits mentioned above which America has derived from its duty-free trade relationship with the Philippines, the following forces will likely favor a reciprocal trade relationship between an independent Philippines and the United States: (a) The 516 million pesos of American capital invested in the Islands will favor such a trade arrangement, since it is the tendency for the flag to follow investments. (b) There is a number of soap and oil factories, as well as sugar refineries, in continental United States which will continue to demand copra and raw sugar from the Islands. They will likely favor the granting of special tariff concessions to Philippine products in the American market. (c) America might wish to see retained the American ideals and

culture which it has planted in the Islands. To perpetuate these ideals, it is necessary that America help in the establishment of an economically independent Philippine government. One of the basic factors of this economic stability is the export trade of the Islands.

The strongest opposition to such a reciprocal trade relationship will likely come from the same farmers' organizations in the United States that succeeded in placing the present limitations on the duty-free entry of Philippine sugar, coconut oil and cordage into the American market. Such opposition will be based mainly on nationalistic appeals.[9] But it will most likely carry weight, because these farmers' organizations are reputed to have one of the strongest political lobbies in Washington. The early consideration of the future trade relations between the two countries will likely depend upon which of the two major parties in the United States will control the American Government after the elections in November, 1936.

5. *Lessening our dependence on overseas sources for the supply of some foodstuffs and other products.* This task will require the diversification of the country's production. Local capital is available for the establishment of new productive enterprises in this country. For instance, there is considerable cash, amounting to 19 million pesos over and above what is required for legal reserves, lying idle in the vaults of the Manila banks. This large sum of money is available for productive purposes.[10] But people go into business on a well-calculated margin of profit, and if they do not see any assurance of gain, they will not take the risk. Raise the prices on the domestic market, to make them attractive and profitable, by enforcing an effective protective tariff against the importation of those products which can be raised or manufactured to advantage locally, and sooner or later local enterprises will supply that market with products produced by themselves. Moreover, a protective tariff will perform a triple service for the nation: (a) It will assure local producers of the domestic market; (b) it would raise revenue for the Government, should imported products still continue

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[9] The duty-free entry of Philippine sugar and coconut oil into the American market has been proven to be not a menace to the sugar and dairy industries in the United States by studies conducted by authorities on the American tariff. (See Lippert S. Ellis, *The Tariff on Sugar*, Rawleigh Foundation, Freeport, Ill., 1933, p. 21; also Ronald R. Renne, *The Tariff on Dairy Products*, Tariff Research Committee, Madison, Wisconsin, U. S. A., 1933, p. 19.)

[10] See report of the Bank Commissioner of the Philippines published in *The Philippines Herald* of May 21, 1936.

to come in; and (c) it will increase the taxable wealth of the country, in view of the possible utilization of lands now lying idle for the production of the protected products.

Should a reciprocal trade relationship between America and an independent Philippines fail to materialize and no effective remedial measures can be found, then the eventual effect of the application of the American tariff on Philippine products will probably be a contraction of the overseas trade of the Islands to about 25 per cent of its present volume. This trade will consist mainly of abacá, copra, leaf tobacco, and lumber. In short, the setback in the economic life of the country, as described above, will be inevitable.

TABLE 1

Value of imports and exports of the Philippine Islands during the Spanish régime, 1831–1895 [a]

YEAR	IMPORTS	EXPORTS	TOTAL TRADE	BALANCE OF TRADE
	pesos	*pesos*	*pesos*	*pesos*
1831	2,417,352	2,293,230	4,710,582	62,061 (—)
1841	4,659,648	6,963,080	11,622,728	2,303,432
1851	6,936,764	8,766,782	15,703,546	1,830,018
1861	21,300,988	16,929,548	38,230,536	4,371,440 (—)
1870	49,044,500	58,436,000	107,480,500	9,391,500
1881	36,970,966	43,735,884	80,706,850	6,764,918
1891	33,609,566	41,722,862	75,382,428	8,163,296
1892	32,620,274	38,316,316	70,937,982	5,696,434
1893	31,786,188	44,481,100	76,267,280	12,694,912
1894	28,490,012	33,070,424	61,560,434	4,580,412
1895	26,104,884	37,674,756	63,779,640	11,569,872
Average 1891–1895	30,526,185	39,063.091	69.585,551	8,537,006

[a] Source: *Census of the Philippine Islands,* 1903, pp. 564–565. The values in U. S. dollars were reduced to their equivalents in Philippine currency by multiplying the figures by 2, there being ₱2 for every American dollar.

TABLE 2

Philippine foreign trade under the American régime by periods of eleven years each, 1899–1931, and yearly, 1932–1934 [a]

(Values in thousands of pesos, i. e., 000 omitted)

PERIODS AND YEARS		TRADE WITH THE UNITED STATES		TRADE WITH ALL OTHER COUNTRIES		TOTAL TRADE
		pesos	*per cent*	*pesos*	*per cent*	*pesos*
1899 to 1909	Exports	219,722	34.4	418,837	65.6	638,559
	Imports	93,624	14.7	542,634	85.3	636,258
	Total	313,347	24.6	961,471	75.4	1,274,817
1910 to 1920	Exports	948,919	55.5	762,365	44.5	1,711,284
	Imports	855,385	54.2	721,806	45.8	1,577,190
	Total	1,804,304	55.0	1,484,171	45.0	3,288,475
1921 to 1931	Exports	2,101,463	73.8	774,082	26.2	2,875,545
	Imports	1,523,489	60.8	977,549	39.2	2,501,083
	Total	3,624,953	67.4	1,751,630	32.6	5,376,628
1932	Exports	165,296	87.0	25,380	13.0	190,676
	Imports	102,595	65.0	56,195	35.0	158,790
	Total	267,891	77.0	81,575	23.0	349,466
1933	Exports	182,626	86.0	28,916	14.0	211,542
	Imports	87,081	65.0	47,642	35.0	134,723
	Total	269,707	78.0	76,558	22.0	346,265
1934	Exports	183,687	83.0	37,120	17.0	220,807
	Imports	108,751	65.0	58,463	35.0	167,214
	Total	292,438	75.4	95,583	25.6	388,021

[a] Sources: Figures for 1899–1931 from the Manila Harbor Board, *The Port of Manila Yearbook*, 1932, p. 11; those for 1931–1934 from the *Annual Report of the Insular Collector of Customs* for 1934.

TABLE 3

Showing annual average value of the following exports to the United States during the period from 1922 to 1934 [a]

COMMODITIES EXPORTED	ANNUAL AVERAGE VALUE SOLD TO U. S., 1922-34	PER CENT SOLD TO U. S.	PER CENT SOLD TO U. S. TO TOTAL ANNUAL AVERAGE VALUE OF ALL EXPORTS
	pesos		*1922-34*
Sugar	91,649,423	94.27	47.05
Coconut oil	33,804,977	96.77	17.35
Desiccated coconut	4,383,023	99.86	2.25
Cigars	7,491,937	81.36	3.85
Embroideries	8,200,674	99.43	4.21
Cordage	1,262,000	49.64	.65
Total	146,792,034	.....	75.36

[a] Annual average value of all exports, 1922 to 1934, ₱194,796,804.

Exports of hats and shells are not considered, because they constitute a very small percentage of the total value of all exports.

MISCELLANEOUS NOTES ON LOCUSTS, AGRICULTURE AND PEOPLE IN MINDANAO[1]

LEOPOLDO B. UICHANCO
Of the Department of Entomology

WITH ELEVEN TEXT FIGURES

The primary object of the trip to Mindanao, on which the present paper is based, was to make an ecological study of representative points on Mindanao and some of the neighboring islands with a view of determining permanent reservations of the Oriental migratory locust. The work is supplementary to the investigation I have been conducting in the Department of Entomology during the past four years on the relation of climate to locust outbreaks in the Philippines.

TIME COVERED

I left Los Baños on April 15 and returned on May 18, 1936, thirty-three days. About ten days of this time were spent travelling in steamships, leaving some twenty-three days on land.

PLACES VISITED

Cebu—Cebu city to Cebu Sugar Co., near Talisay; Mandawe; Naga. Mindanao—Surigao to Jabonga, via Lake Mainit; Cabadbaran, via Santiago; Butuan. From Butuan, by boat to Mambajao, Camiguin Island, then by bus to the other side of the island, at Bononi. From Bononi, by launch, to Talisayan, Oriental Misamis, then a long ride by bus to Cagayan. Bukidnon province was explored clear through to Malaybalay and Valencia. Lanao province, from Iligan to Dansalan, via Maria Cristina Falls, then along the shores of Lakes Lanao and Dapao to Ganasi and then to Malabang. From Malabang, by launch, to Cotabato, and then by bus to Upi.

It had originally been my intention to go farther into the interior of Cotabato province, at least as far as Kabakan, but the time I would have required would have been a week or more, on account of very poor and uncertain transportation facilities. I learned much to my chagrin and personal inconvenience that even to the boats of the large interisland steamship companies, when calling at Cotabato, time meant nothing. The boat I took, for instance, from Cotabato was announced to sail in the evening; I had to rush everything to catch it on schedule. It did not leave till late the following morning.

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[1] Experiment Station contribution No. 1148. This paper forms part of a report to the President, University of the Philippines, who kindly authorized its publication.

At Zamboanga, I could cover only 35 kilometers by road to Labuan, via San Ramon Penal Colony, another 35 kilometers to Bolong, and 5 kilometers to the public park at Pasonanca. Davao—Davao city to Panabo; Davao city to Santa Cruz and back to Bago and to Eden Plantation. Basilan Island—Lamitan to Isabela; Maluso.

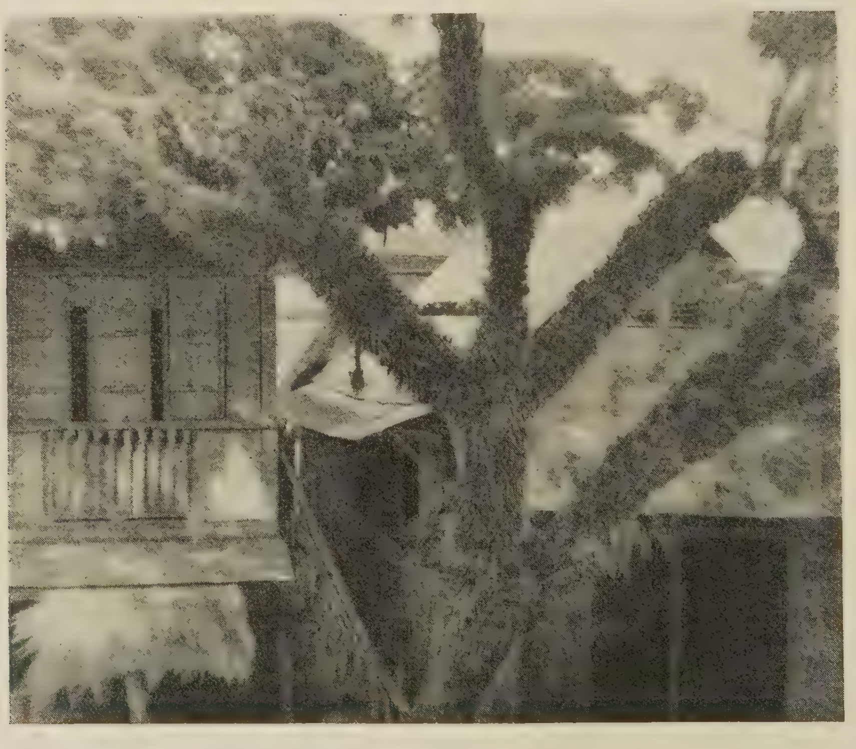

Fig. 1. Surigao, Surigao Province: Typical epiphytic growth, mostly *Orymoglossum heterophyllum*, on limbs of the rain tree.

Steamships in which I was a passenger also called at the following points: Maribojoc, Bohol; Burias Island; Panaon Island; Maasin, Leyte. Unfortunately, because of the absence of docks, I was unable to land, although I made what distant observations I could from the steamship.

METHODS OF OBSERVATION

Most of the observations were made along the roads that could be reached by autobus or by automobile. This procedure enabled

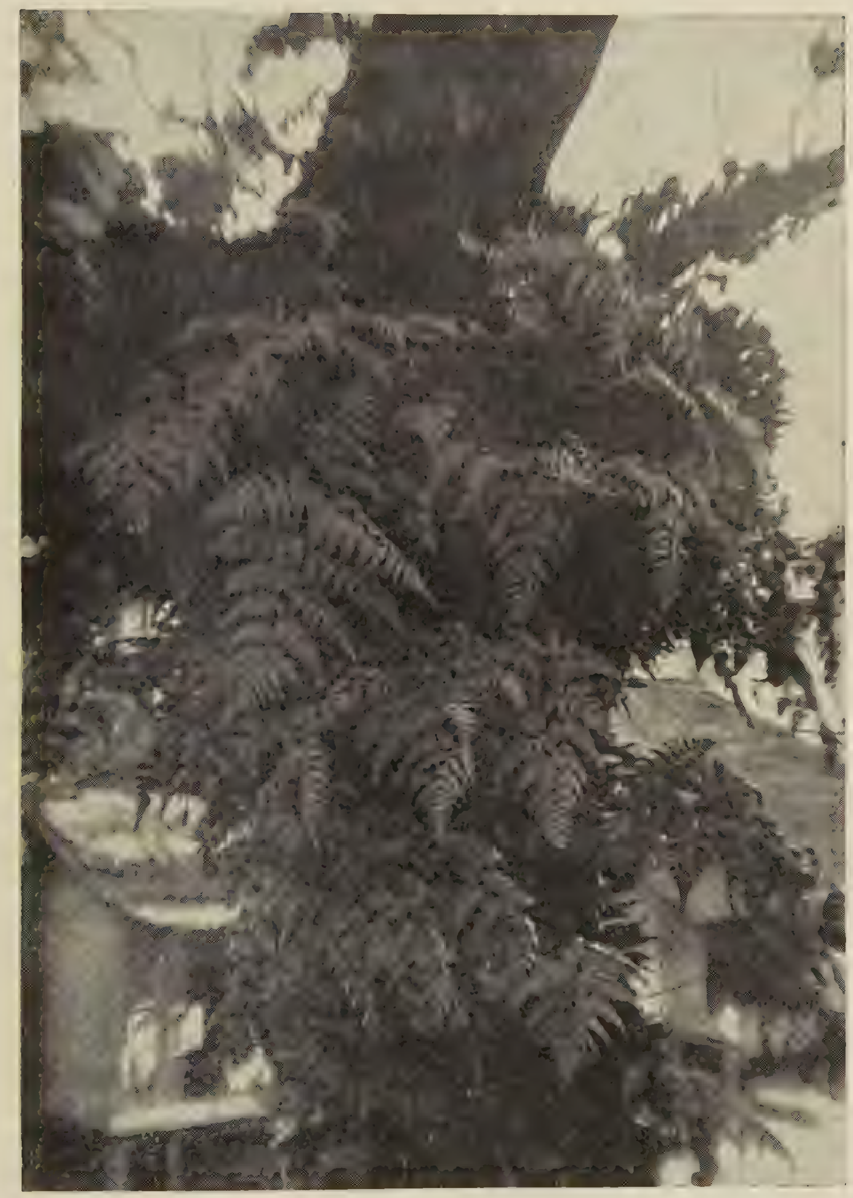

Fig. 2. Surigao, Surigao Province: Another common epiphyte, *Dryopteris* sp., on limbs of the rain tree.

me to cover very wide territories in the short time at my disposal. Autobuses were preferred to automobiles, not only because the fare was about one-tenth as cheap but also because they ran at a pace slow enough for satisfactory observation. Between bus connections and whenever bus made a fairly long stop, advantage was taken of the time to go farther on foot in order to make more detailed studies and to collect specimens. At what I judged to be critical areas in Mindanao, I made longer stop-overs of one-half day or longer. In certain places, like Malabang, where the movements of the launch depended on the uncertain rise of water of the Mataling River, I was marooned for three days, occupying myself with collecting in the neighboring woodlot whenever I was not excitedly chasing back to my lodging house everytime I heard what my guide and I thought was the whistle of a departing launch. I nearly had the same experience in Agusan, where some bridges were washed out by heavy rains soon after we had passed on to Butuan from Santiago.

Plants as indicators of prevailing climate were used considerably in evaluating meteorological features, especially rainfall distribution and humidity. In the absence of weather data for many of the localities considered, this method of approach was the only alternative. Moreover, even with such data on hand, phytometers (plant indicators) and zoömeters (animal indicators), when used cautiously, constitute an essential supplementary clue to local climatic trends. Then again, correlation of these observations with the generalized locust climatographs I have in the laboratory furnishes the necessary corroboration.

SOME ECOLOGICAL RESULTS

A general observation that may be mentioned is that all parts of Mindanao visited, except along a narrow strip on the Misamis coast, were characteristically very humid, with rainfall fairly evenly distributed throughout the year. This condition was shown by the presence of species of *Melastoma* and ground ferns even at about sea level. *Melastoma* is usually found in Luzon, with the possible exception of the eastern coast and the Bicol Peninsula, at the moist higher elevations, above 800 meters. On the northeastern coast of Mindanao, as in the town of Surigao, the rain trees (*Samanea saman* [Jacq.] Merr.) growing at about sea level have the branches densely covered with mosses and such epiphytic ferns of the family Polypodiaceae as *Orymoglossum heterophyllum* (L.) C. Chr. (see fig. 1) and *Dryopteris* sp. (fig. 2). Rain trees in Cebu, and to a more limited extent even in Manila and Los Baños, are, to be sure, also found with *Orymoglossum* growth on the branches, but in our Luzon places they have never been seen so thick as in Surigao. The iron roofs of many houses were green with unicellular algae. Some papaya seedlings were seen sprouting on a nipa shed. So characteristic, indeed, are the Surigao rain trees that they cannot help but impress the casual visitor. Hence, I was amazed when I noticed around the Surigao high-school premises some exceptional rain trees of which the limbs were clean and free from growth. Upon inquiry, I learned that these trees were purposely scrubbed of epiphytes—manicured—by order of the division superintendent of schools, preparatory to one of the contemplated visits of President Quezon to the place.

So wet is the northern tip, and probably the greater part of the eastern coast, of Surigao that the soil must be either too badly leached out or too poorly aërated for agricultural purposes. I was informed that in the past season's crop, an average of only five cavans of rice could be harvested from a cavan of seed. A part of this failure, of course, is probably due to poor cultivation, because, from the sloppy construction of many of the houses and the neglected condition of the fields, the Surigao people in the places I visited did not impress me much as to diligence. The climatic conditions doubtless contribute greatly to this seemingly general apathy, for there was hardly a day while I was there in April (supposedly the height of our dry season) when it was not either overcast or raining. I could find no useful crop that was grown with conspicuous success in that locality, although recent developments in mining are now beginning to make Surigao a boom town.

Before I started on my trip to Mindanao, I had, on the basis of climatic correlation, been using the abacá (*Musa textilis* Née) as a guide to indicate locust-breeding places. My conclusions were that permanent locust reservations are apparently limited to Philippine areas where the abacá grows best. Abacá and locust conceivably exhibit the same ecological requirements. The intensity of abacá, according to Wester (1920), was confined along the watersheds of the Agusan River and its tributaries, in the canyons of Bukidnon between the plains in the southeast towards Davao, in the Talakag districts, and around the Davao Gulf.[2] In the typical abacá places visited in Davao, ground ferns, particularly *Dryopteris dissecta* (Forst.) and *Nephrolepis hirsutula* (Foster) Presl., are common, but *Melastoma* is absent or probably rare. The presence of many termite mounds, which cannot exist where there is excessive soil moisture, side by side with ground ferns, which, in nature, grow only on places where adequate soil moisture is present indicates an even distribution of moderate rainfall throughout the year. Likewise, the epiphytic growth on rain-tree limbs in Davao is rather sparse.

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[2] The Philippine Agricultural Review 13: 25-37; 38-56; 100-111; 137-154; 155-172; 237-251; 252-264. 1920.

With respect to ground ferns as indicators, it was found important to discriminate among the various polypodiaceous species, inasmuch as certain forms, such as the cosmopolitan bracken, *Pteridium aquilinum* Kuhn, are associated with poor soil, rather than suitability for abacá culture. Likewise, between *Dryopteris* and *Nephrolepis,* the former is apparently a more reliable indicator, inasmuch as *Nephrolepis* can sometimes grow in places that are not peculiarly suited to abacá cultivation, such as on the soil under the coconut groves in San Pablo, Laguna, during the rainy season. In Davao, however, for instance, around Panabo, *Nephrolepis* is present here

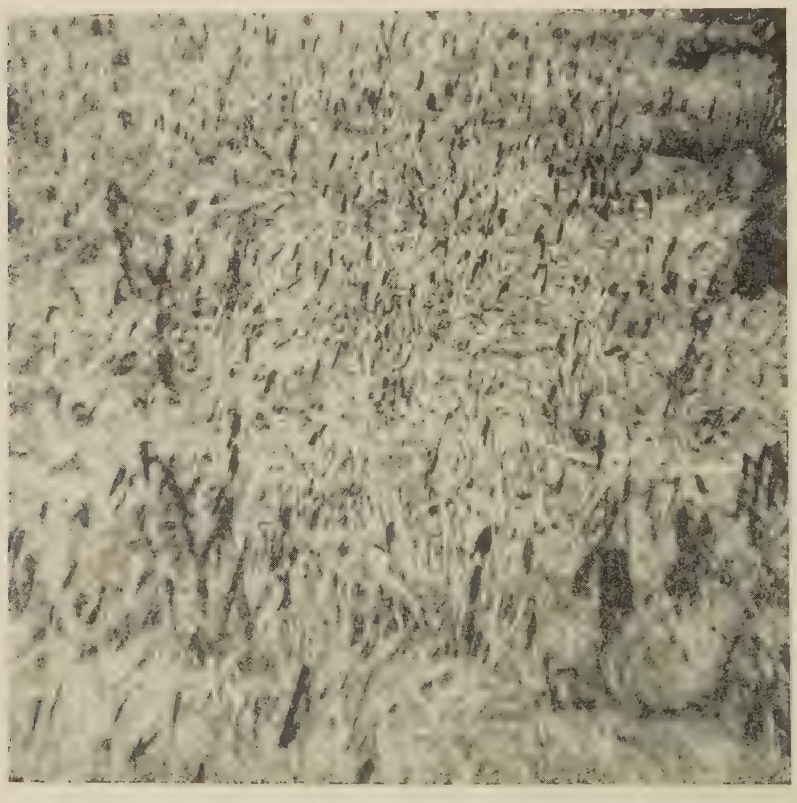

Fig. 3. Hungry hoppers teasing out the last green shreds from grass stubbles in Valencia, Bukidnon Province.

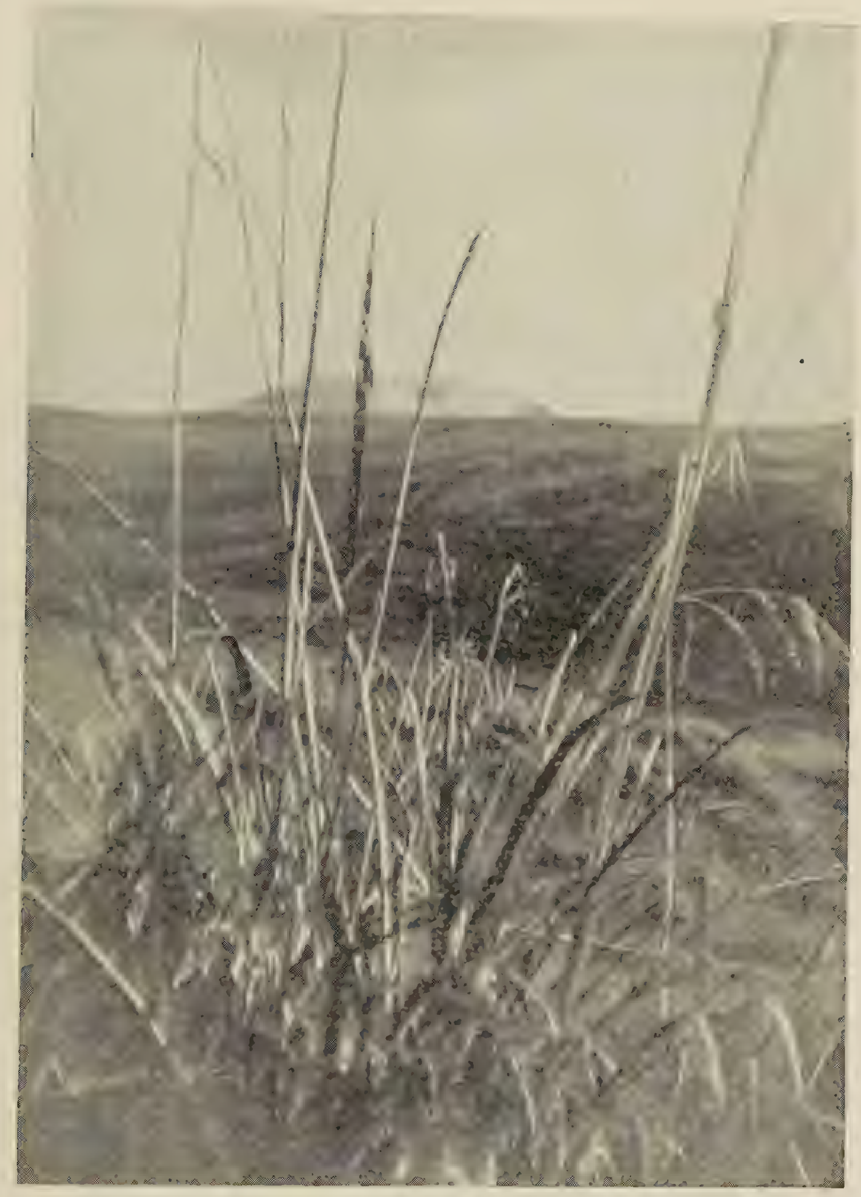

Fig. 4. Malaybalay, Bukidnon Province: *Themeda gigantea*, an important pasture grass, which is a favorite food of locusts.

and there in very thick stands; in Laguna only very occasional and isolated plants are met with.

Coconut grows well in Davao, and the trunks were much more robust and the nuts bigger than those I saw in the famed San Ramon District at Zamboanga. Coconut, however, is not as good a phytometer for locusts as is the abacá, because it can stand a much drier condition and a less even distribution of rainfall.

The relation of locust reservation to abacá is, likewise, amply proven by the records of the present cycle of infestation, where outbreaks occurred first and the duration was most persistent in and around the abacá districts.

LOCUST SITUATION

At the time of my visit in Mindanao, all the provinces of that island were locust-infested. But perhaps about the worst affected was Bukidnon. So thorough were the locusts in their work, that, before entering the province, as I went through the northern coastal road of Oriental Misamis from Talisayan to Tagoloan, the visible portions of the Bukidnon plateau appeared like a monstrous wall of ugly clay-red barrenness. The grass was stripped bare to the ground. The hoppers were so hungry on the plateau that they even gnawed off portions of pineapple leaves. On my way to Malaybalay, I met a flock of some thirty head of cattle which were being driven to the coast after having been sold to dealers. Every one of these animals had the ribs sticking out, so famished had they been in the pasture (see fig. 5). One of the most useful Bukidnon pasture grasses, *Themeda gigantea* (Cav.) Hack. (fig. 4), happened to be a favorite food of locusts. Likewise, two bad species of weeds had been working in conspiracy with the locusts in crowding out the pasture grasses—*Hyptis suaveolens* Poir. and *Helicteres angustifolia* Linn. That the livestock problem does not become any worse than it is now is due mainly to the wide pasture ranges allowed the animals. Likewise, it must be borne in mind that Bukidnon is a high plateau, which reaches to about 1000 meters near Malaybalay. Although the ancestors of domestic cattle are lost in antiquity, it is presumed to be closely related to the aurochs (*Bos primigenius*)[3] of medieval central Europe, the temperate climate of which could begin to be approached in the tropics only at high elevations. Hence, the relative adaptability of Bukidnon to cattle ranching.

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[3] According to Hertwig and Kingsley (Hertwig's Manual of Zoology, 1912, p. 569), "domestic cattle probably descended from three distinct stocks (*B. primigenius*, aurochs, *B. longifrons*, and *B. frontosus*)."

In Agusan, Lanao, Cotabato and Davao, the locust situation did not seem to be quite as generally serious, except here and there in places. A wide territory was reported to be in the grip of locusts in the Sebu and Coronadal valleys in Cotabato, but I was not able to visit these places, on account of the difficulty in making connections. Mr. Luis Uranza, of the Bureau of Forestry, whom I requested to look up conditions around that locality during his forest-survey work there, writes from Santa Cruz, Davao, under date of August 30, 1936:

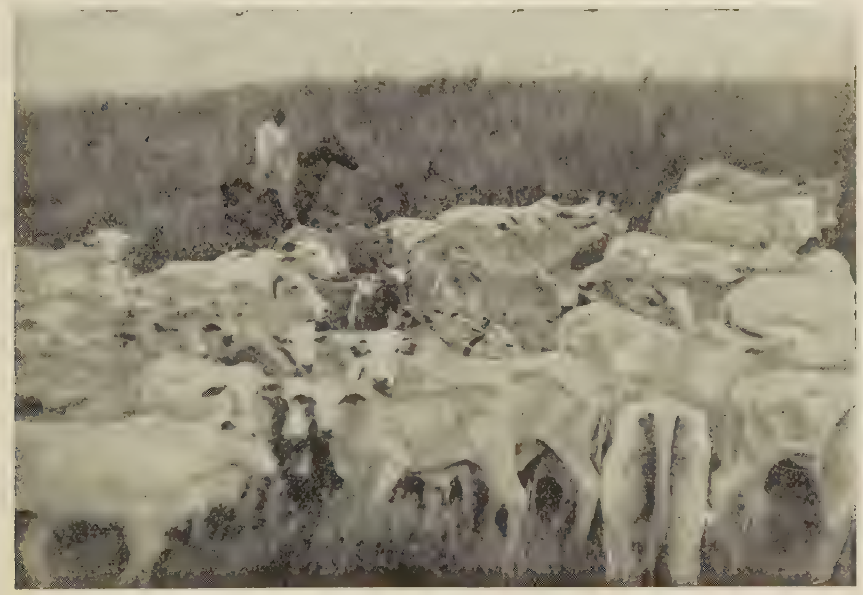

Fig. 5. What the locust did to cattle in Bukidnon Province.

"Just 16 to 20 kilometers from Kidapawan towards Davao are plenty of locusts. They hibernate [breed] among the tall grasses in the barrios of Quisante and Balatucan [Cotabato, near the Bukidnon border]. According to the natives, these locusts spend [go through] their life cycles around those places only. They never go very far. This morning I went to Davao and along the road are plenty of young and old [adult] locusts." The foregoing information is significant and is worth following up. It is quite probable that an ever-presence of locusts, which must have led the natives to believe that "they never go very far," is an indication that the barrios of Quisante and Balatucan are situated in the permanent reservation. More so, because my own theoretical findings, using climatic features as a measure, would include these places in what I concluded should be permanent reservations for locusts.

SOME FIELD OBSERVATIONS ON LOCUST HABITS

Along the coasts, standing coconut trees had their leaves stripped off by locust fliers. I observed cases of this kind around San Pablo, on the western shore of Lake Mainit in Surigao, and in different places, always bordering a coast, along the way through Oriental Misamis, Camiguin, Lanao, Cotabato, and Jolo. The coconut leaves are not a normal food of locusts, but, as the insects settle down after a long flight, their tendency is to pass the night as high up as they can climb. They evidently chew coconut leaves in order to extract enough moisture to freshen themselves up.

Some observations were made on the relation of temperature to swarming of hoppers at Malaybalay in the morning of April 26, 1936. At 6:15 a. m., when the grass temperature was only 22°C, the hoppers remained inactive in presumably the same position they had maintained during the night. The young, newly hatched hoppers were thick on the low grass, while the older ones were clustered among the leaves and overtopping panicles of *Themeda gigantea*. They did not begin to feed until 6:58 a. m., when the grass temperature rose to 27.0°C. Some aimless hopping was noticeable at 7:03 a. m., when the grass temperature became 27.6°C. The larger hoppers were setting the disturbance and the little ones were following suit. By 7:14 a. m., grass temperature 29.0°C, most of the nymphs were down from their roosts. At 7:50 a. m., grass temperature 33°C, all the hoppers were actively swarming, with a definite direction.

Near Butuan, in Agusan province, where the hoppers were following the provincial road, they were especially thick along vehicle tracks. The wheels of automobiles and animal-drawn conveyances crushed them on the ground. More hoppers came, to eat the dead hoppers. Wheels crushed more of them. Still more hoppers came to eat, and so on, with the result that every automobile or other wheeled vehicle became inadvertently an effective locust fighter.

CONTROL MEASURES AGAINST LOCUSTS

The method primarily resorted to was the use of poisoned bait, the base of which was bagasse. At the Cebu Sugar Co., a considerable quantity of this bait was prepared for distribution to neighboring islands. In my observations on hoppers at Malaybalay mentioned above, I noted that, as a result of application in the afternoon, very few were dead the following morning. The ones most affected were the young nymphs, while none of the older hoppers even looked groggy. I was assured by the man on duty in bait application that the living ones I saw marching on their regular migratory activities had also partaken of the poisoned bait during the evening, and that sooner or later they were going to die. However, I had to leave for Cagayan de Misamis by noon, so I was not privileged to witness the fulfillment of his promise.

Perhaps if the bait could be seasoned with a certain amount of the locusts that were killed in the campaigns, its attractiveness might be enhanced, just as the Butuan hoppers were drawn to the bodies of their dead comrades along the wheel tracks. Our past cage experiments at Los Baños with adding locust meal to bagasse bait had proved negative, but then we were using dried, and not fresh, locust meal on locusts that had been bred in confinement for generations. The effect may be totally different in the field under locust-swarm conditions in Mindanao.

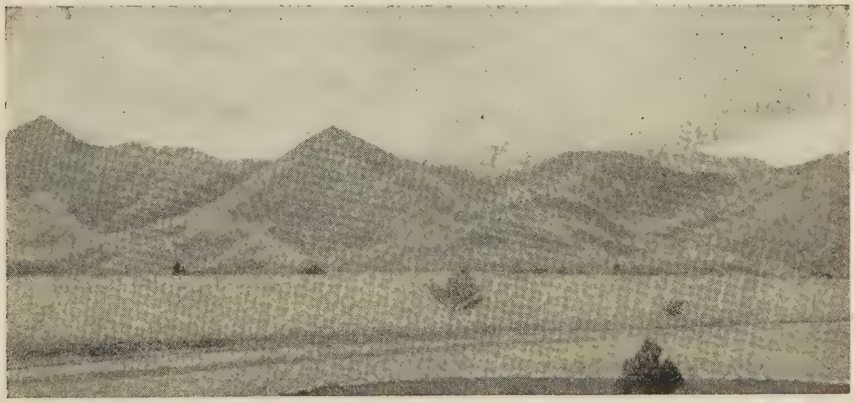

Fig. 6. Bukidnon Province: View from golf course at Malaybalay, showing mountain range laid bare by locusts.

OTHER INSECT PESTS

Cockchafers, or salagubang. In Malaybalay and vicinity, branches of mangoes and other trees were heavily laden with adults of *Leucopholis irrorata* Chevrolat and another related melolonthid species. A litchee tree near the Protestant chapel along the provincial road had the leaves black with beetles and the branches weighted down by this extra burden. I have yet to see a place that is so rich in these beetles. Because their young are the destructive white grubs, this pest must offer a serious entomological problem in Bukidnon.

Abacá-stem weevil. A bad weevil pest, *Odoiporus longicollis* (Olivier), quite similar superficially to our familiar *Cosmopolites sordidus* Germar (banana and abacá root weevil), but larger and otherwise certainly very distinct, was threatening to destroy the abacá industry in certain parts of Davao. I had occasion to examine infested plants above the Eden Plantation, beyond Bayabas. While *C. sordidus* confines its work to the underground parts of abacá, this Davao weevil works through the entire length of the stem and renders the plant useless for stripping. I was told that *Odoiporus* prefers the Maguindanao to the Tangongon variety, but both are equally attacked. The pest seems to confine its destructiveness to plantations located above an elevation of 800 meters, toward Mt. Apo. This case furnishes one excellent example of a theory I have been trying to develop, that certain of our serious insect-pest problems apparently have their solution in an intelligent consideration of the natural habitat of the host plant. Abacá grown at elevations lower than 800 meters in Davao are free from this weevil pest because, for one thing, they are in such a state of growth as to be non-receptive to that pest. Abacá in nature is a jungle plant, and jungles are not found at excessively high elevations. Likewise, by way of further examples, coconuts in dry, or otherwise unnatural, environment for coconuts, are subject to the attack of leaf miner and rhinoceros beetle. Coconuts require among other conditions a fairly even rainfall distribution throughout the year for normal development. In Davao, cacao pods are severely injured by the larva of a tineid moth, *Acrocercops cramerella* Sn. We also have the same pest species in our part of Luzon, but it is not so serious among us here, presumably because cacao growth under our conditions renders their pods non-receptive. In part with this idea in mind, I was quite amazed to find cotton-growing being advocated around Butuan, Agusan, where Weather Bureau records for 31 years indicate continuous mean monthly rainfall of 105 to 330 mm. and average number of rainy days per month of 14 to 22. Cotton needs at least three continuous dry months.

GENERAL FEATURES OF THE MINDANAO INSECT FAUNA

A fairly representative sample of the lowland and middle altitude forms of various orders has been secured on different points, enough at least to show some of the more important zoögeographic relationships of certain parts of Mindanao. One striking characteristic of this interesting island is that at lower elevations, down to almost sea level, certain insect species are found which in Luzon are almost exclusively features of the highland fauna. In this respect, they are quite similar to the flora in distributional trends, and these can doubtless be explained by the striking difference in general climatic features between Luzon and Mindanao.

A FISH STORY

In my lodging house at Jabonga, I was served a fish dish which I was willing to swear was the best fish I ever tasted. I had seen this fish earlier in the day, when a man, alighting from the launch I was to take at Mainit, was carrying a number for sale. This fish was known in that place as *guingao* (fig. 7), and was a transient from the sea. Upon my return to Los Baños, I acquainted the Fish and Game Administration with my experience and repeated to them my love song for the *guingao*. Dr. D. V. Villadolid, of that office, who examined the picture, had to hand me the cold, scientific verdict that my wonderful *guingao* was none other than *Lutjanus argentimaculatus* (Forskal), of the family Lutjanidae, which in Pansipit is known as *alsó*. I had eaten fairly liberally of the Pansipit *alsó;* but it never made the impression on me that the *guingao* did. The reason, I suspect now, is that I had been quite famished during the tedious and uncertain trip from Surigao to Jabonga. Eating facilities along the way, if and when they could be secured, were very

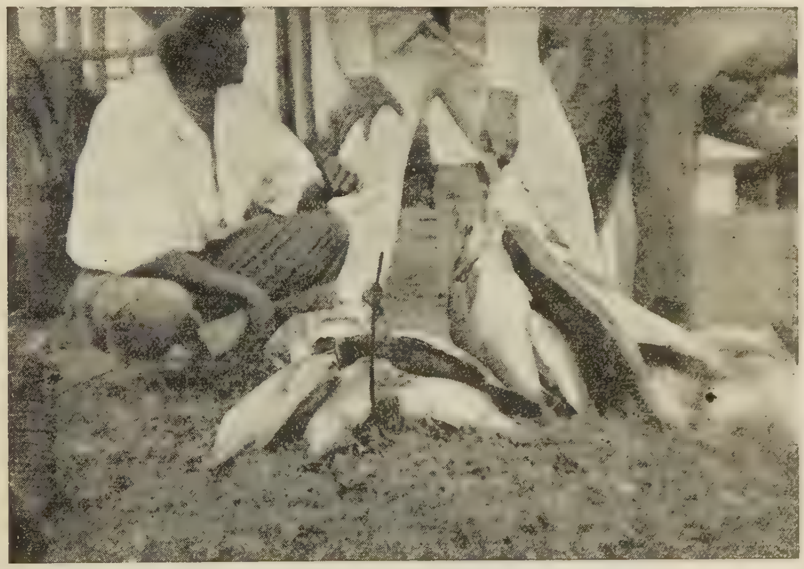

Fig. 7. The guiñgao, *Lutjanus argentimaculatus*, a most delicious transient fish in Lake Mainit.

poor. On the other hand, my own home is not very far from Pansipit. Likewise, Doctor Villadolid suggests, the Pansipit *alsó* usually remains captive too long in the corral, thereby becoming worn out and tasteless; on the other hand, the *guingao* of Lake Mainit is caught while enjoying its freedom and cooked in all its delicate tenderness.

PEOPLE

On landing at Cebu, one's attention is particularly struck by that curious horse-drawn vehicle, called "tartanilla", which is identical in most respects with the "sado" of Java. Whether this identity reflects a common original home of the Cebuans and the Javanese at some remote past, I am not prepared to say. The fact, however, is that Cebuano influence is exceedingly marked all over the Christian part of northern Mindanao, from Surigao to Cagayan de Misamis, and even far into Iligan, where "tartanillas" are a common sight. So dominant is the Christian element in most of the northern part of Mindanao, as a result of immigration from the Visayas and, to a certain extent, also from Luzon, that some kind of Visayan is spoken all over the place. Many of the practices are doubtless characteristically Visayan. The *tubá* (fermented palm sap) is reddened by the addition of a tan-bark, "tañgal", *Ceriops tagal* (Perr.) C. B. Robinson. The tannin of this bark is an astringent which serves to counteract the laxative effect of the *tubá*. I did not realize that this drink was strong until I unwarily accepted a large tumblerful in the home of a Constabulary lieutenant at Malabang. It was so deceitful in its sweet and pleasant taste.

The pickled *dilis* (anchovies) which in our part of Luzon is deep red with *angkak* (*Monascus purpureus*) and is known as *bagoong*, is not colored at all in Mindanao. In Surigao, I saw on sale in many stores, alongside with *kangkong* (*Ipomoea reptans* [Linn.] Poir) shoots, young leaves of a tree, called "bago", *Gnetum gnemon* Linn. (Gnetaceae, Gymnospermae), which, I was told, is used considerably as a vegetable.[4] The nipa bundles for thatching everywhere in northern Mindanao are unusually long—over one meter.

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[4] Brown (1921), in *Minor Products of Philippine Forests*, vol. 2, p. 245-246, states, "The fruit is eaten either boiled or roasted, while the young leaves are frequently used as a vegetable. This species is commonly cultivated in some of the towns of Batangas province, Luzon, for its edible leaves and fruit." Citing Heyne (*De Nuttige Planten van Nederlandsch-Indie*, vol. 1, p. 20), he adds that in Java "the young leaves, flowers, and fruits are favorites for stews. . . . the ripe fruits are roasted and pounded while hot into thin, round cakes which are cooked in boiling oil, when they puff up into a porous, crisp cake called *krupuk*."

While on a launch on Lake Mainit, toward Agusan, I could see here and there along the western coast Negritoes and Manobos, whom, however, we did not approach close enough to have a good view of. These people, I was told, had a curious custom, which in some respects must have been a forerunner of our modern preventive medicine. If a person dies in the family, they desert the house, and build another one at a considerable distance. These primitive pagans, of course, run away in fear some mysterious evil spirits, which cause disease and death, contagion to these people being but a proof that the unseen agents still haunt their old home.

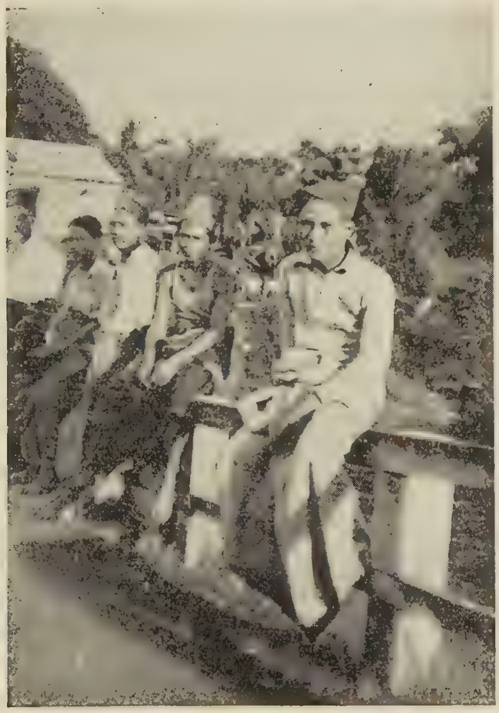

Fig. 8. Maranao Moros in Dansalan, Lanao.

It was not until I reached Iligan that I began to breathe the exotic air that Moro communities impart to a place. More so at Dansalan, where the Maranao, with his brilliant-hued *malong,* lends brightness to the streets and to the market-place (fig. 8). Early in the morning, the entire Moro population is wont to pass in review along the banks of the Agus River in order to perform their sanitary duties. The morning view from my hotel window at Dansalan was enlivened by rows of squatting figures, with the nether ends of their trunks carelessly bared to the playful strokes of the water current.

The Maranaos impressed me as a happy, carefree people, individuals of both sexes loving to dress gaudily; and in their talk, as loud as in their clothing. Even the gumamela (*Hibiscus rosa-sinensis* Linn.) and the macopa (*Eugenia malaccensis* Linn.) bear characteristic brilliant red flowers, as if to harmonize with Moro taste. The more opulent datus embellish their houses with intricate carvings on the woodwork. I had the privilege of visiting the interior of two—one in Dansalan and another at Ganasi. An example of the loving care bestowed on Moro houses is furnished by the datu's house at Ganasi (fig. 9). It has now been under construction for some fifteen years, and it is not yet finished. One suitable piece of wood is chosen at a time and designs engraved laboriously, before another piece is acquired.

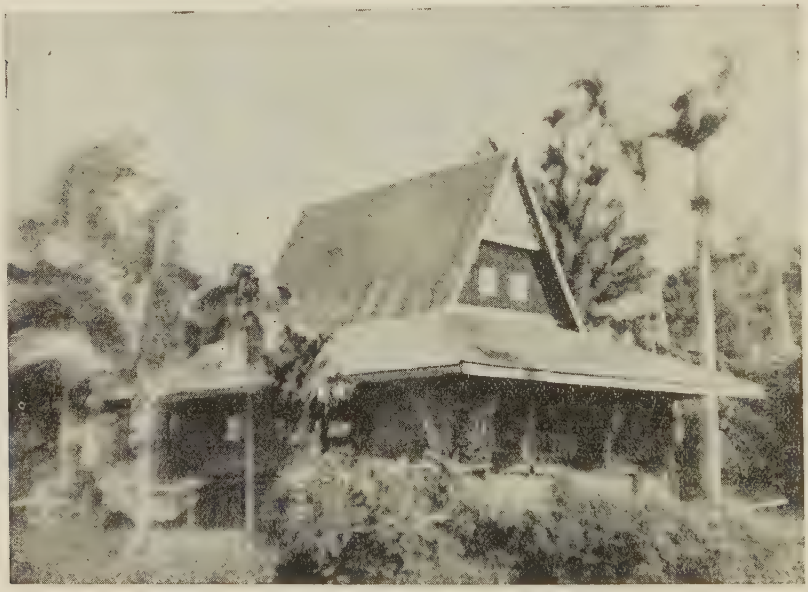

Fig. 9. A datu's house at Ganasi, Lanao.

Once, while walking in company with Doctor Merino and two bureau inspectors along the streets of Dansalan, I heard the Maranaos talking, the words I could distinguish being, "Filipinos, Filipinos." They were Moros, and we were Filipinos! They evidently were careful to preserve this distinction; before their Moslem eyes, their Christian brethren—infidels—from the north must cut a sorry figure,

> "Which hath been smooth as oil, soft as young down,
> And therefore lost that title of respect
> Which the proud soul ne'er pays but to the proud."

Perhaps typical of the queer turn of Moro psychology is the fact that the grave of the notorious bandit Dimakaling, in Tugaya, which is his birthplace, is a shrine to which many of the worshippers of Allah pay homage. The admiration for feats of daring, even though done treacherously, which made Spanish expedition to Mindanao and Sulu during the past centuries nothing more than successful raids at best, is still a prominent Moro feature. Our automobile drive from Dansalan to Lake Dapao, in a car belonging to the provincial government of Lanao, was rendered exciting by a few large bamboo poles strewn here and there across the highway and a flat tire from a four-inch nail purposely planted in the wheel track for our special benefit.

Even in Jolo, with its evil reputation among us in Luzon, the people were, superficially at least, peaceful and tractable. Of course, I was somewhat uneasy while on that island; I had read and heard so much about the *juramentado*. Fortunately, I was spared this gruesome experience, although I had no other companions but Moros, one of whom was our former graduate, Mr. Banao Dalid. We penetrated the forbidding interiors of Jolo, even Parang and Taglibi, which used to be the headquarters of pirates that sowed such terror among the inhabitants of Batangas, Ilocos, and Visayan coasts during the Spanish times.

At Lapa, near Maimbung, I had my first close view of the Samals (fig. 11). These curious people are said to have come to the Philippines later than the Moros. They build their houses on the water near the seacoast. Access to their dwellings is possible only by vinta.

Curiously enough, although Zamboanga is the gateway to the land of the reputedly fierce Moros, the people there, Moros, Samals, and Christians alike, were among the mildest-mannered I have ever met. As the steamship docked at the pier, cargadors came on board and politely asked a passenger, "May I carry your baggage, sir?" When informed that there was none, they answered, "Thank you, sir." Manila and Cebu, especially the former, which cities appear to have a monopoly of the worst-behaved ruffians among cargadors that ever boarded a vessel, might well take a lesson from Zamboanga. Zamboanga, in fact, has other things that she might show Manila,

Fig. 10. Maria Cristina Falls, a beauty spot in Lanao Province.

such, for instance, as its extensive well-laid and ideally located public park, not in the congested heart of the city, but some five kilometers distant, at Pasonanca. Pasonanca's carefully arranged trees, artificial lagoons, neatly trimmed hedges, and easily accessible natural shrubberies and forests, with footpaths running through, make of this a real botanic garden, which might in time prove a good rival to those of Buitenzorg and Singapore. Unfortunately, at Pasonanca, the planted trees are monotonous in their sameness and none of them bears a label. Likewise, the artificial ponds are too small and shallow for the accommodation of the otherwise beautiful Victoria Regias.

Fig. 11. A group of Samal boys in Jolo Island.

AGRICULTURE

The farms of the Maranaos were in small lots, which were mostly planted to rice, with corn at every fourth row. The rows were wonderfully straight and the field remarkably free from weeds. The Joloanos did not impress me as being such meticulously careful farmers as the Maranaos, but, at that, they were better than the ordinary run of the Christian farmers in Mindanao, whose fields, as I saw them, appeared unkempt by comparison. The Moro fields are fenced, usually with bamboo, to keep animals away. The bamboo used is the boho (*Dendrocalamus merrillianus* Elmer), spiny bamboo (*Bambusa spinosa* Roxb.), our common structural bamboo, being absent or very scarce.

Camoteng kahoy (*Manihot utilissima* Pohl) is also a favorite crop among the Moros. An enterprising Chinese in Jolo city has taken advantage of the Moro appetite for cassava starch by erecting a small starch factory, which is operated by machinery. Sago palm (*Metroxylon sagu* Rottb.) grows wild in many places on swamps in both Mindanao and Jolo, and this is, likewise, a source of starch.

Fruits are very abundant. At the time I was there, *huani* (*Mangifera odorata* Griff.) was in season in Jolo, and durian (*Durio zibethinus* Murr.), in Davao. Lanzones (*Lansium domesticum* Correa) seems to be at home everywhere. At Gingoog, Oriental Misamis, a large forest consisting of a pure stand of lanzones is said to have been declared a reservation by the Bureau of Forestry. The *bauno* (*Mangifera caesia* Jack) grows wild and could be seen in forest clearings, especially in Surigao. Tapul Island is noted for its oranges, which is said to be sweeter and to possess a better keeping quality than the Batangas mandarin. Of the mangoes, only the *huani, paho,* and *pahuhutan* grow in Mindanao and Jolo. It is too rainy there for either *carabao* or *pico* mango. All the mango trees I saw had the leaves whitened by the attack of a leaf-hopper, *Typhlocyba nigrobilineata* Melichar.

From Sinai to Ladindingan, in Oriental Misamis, tobacco is said to be an important crop. As I went through the road in this district, I was struck with the unique house-window plants. They consisted of only one kind—tobacco seedlings. Each seedling was carefully grown in its miniature individual pot, a little tube made of banana or palm leaves. These were arranged on narrow bamboo or wooden frames of convenient lengths for hanging up.

The University Forest Reservation at Basilan

The place is located in one of the richest parts of the island. I was informed by the district forester of Zamboanga that this grant, which covers some 5,000 hectares, is expected to net the University a total of not less than ₱750,000 in forest charges alone. After the forest is cleared, the land appears to have excellent agricultural prospects, situated as it is in the rapidly developing district between Isabela and Lamitan. Coconuts grow well in the neighborhood. A flourishing rubber plantation is not far from the place.

Successful farmers

In many places, especially in Agusan, Bukidnon, Davao, Cotabato, and Basilan, I met a few notably prosperous farmers, whose records would read like a page from Horatio Alger. Many of them started with nothing or almost nothing. Through persistence, in combination with good luck, they managed to attain their present positions. At Lamitan stands an imposing residential house—a palace. It belongs to a former student of this College, Mr. Ambrosio Navarro. He had been in this College a couple of years or so in the earlier days, working his way through as a houseboy of one of the American professors. The story of our Florentino Cruz is well known. Even a small-salaried employee could point to me with justifiable pride a property of his of rich fifty-hectare strip of bearing coconuts. Of course, it is hard to tell how many others sought their fortune in Mindanao and failed.

Japanese in Davao

The feeling of a Filipino in Davao must be like that said of Americans in New York. He is in a foreign city, but without his own consul to go to in case of trouble. From the standpoint of economic development, however, the Japanese must be credited with the notable work they have done in that part of Mindanao. If they have profited by their ventures, surely Filipino sharecroppers and laborers have, likewise, benefited in being able to earn a good livelihood, which is reasonably steady because they are dealing with organized concerns. At the Ohta Development Company, I was shown through the abacá-press building where about 200 laborers, all Filipinos, were engaged. I was told there that several thousand Filipino laborers are used in the plantations, and that they have come to prefer the Filipino to the Japanese laborers for the very practical reason that the former are better adapted to the local climate. Most of the laborers come from Cebu and Bohol, although, the Boholanos, so I was informed, are in general more desirable, because they are on the whole better workers and are less prone to pick up a quarrel.

The premier crop in Davao is, of course, abacá. At present the popular varieties are Maguindanao and Tangongon. A recently developed variety, Lauang, is said to be gaining favor. There are two other common varieties grown. A visit to the Japanese abacá plantations is, indeed, an education in good farming. The vigorously growing hills, which indicate a suitable climate combined with conscientious care, are set in quincunx, the arrangement so regular that the rows look like a gigantic military dress parade. The soil between the rows is so remarkably clean that one feels as if he ought to remove his shoes before entering the plantation, just as he would in a Japanese home. The Japanese in this respect are probably the only farmers in Mindanao that would not suffer by comparison with the Maranao rice planters of Lanao.

Colonies

I had a chance to visit only one penal colony, that of San Ramon. This place was a model of cleanliness and orderly arrangement, with all the inmates engaged in some useful occupation, particularly along agricultural lines. The assistant superintendent and a number of subordinate assistants are graduates of the College of Agriculture. There were also carpentry shops, a soap factory, and a brick kiln, so that the convicts have a variety of choice as to occupation in which they could acquire vocational training, in order that they might be reconditioned into good free citizens. These penal farms are, likewise, potential distributing centers in Mindanao for improved strains of plants and domestic animals, especially the latter. It was only at San Ramon that I saw recognizable breeds, such as the Berkjala pig and the Los Baños Cantonese chicken. Everywhere else I went to in Mindanao, the pigs and chickens that greeted me, particularly in the streets, were of nondescript mongrel stock. In the town of Surigao some of the shoats bore longitudinal stripes and long snouts, thus implicating some itinerant wild boar in their paternity. The stripes were sometimes set against the background of a reddish brown coat of the noble Duroc-Jersey breed.

San Ramon Penal Colony will also be remembered as the place from which during Spanish times a convict from Cavite, whose name was Pedro Cuevas, escaped and wormed his way into Basilan Island. There he ingratiated himself among the warlike Yakans by his bravery, until finally he became their datu. In this way, he won the island over to Spain. As a recompense, the Spanish Crown, not only pardoned him, but also offered to deed to him and to his descendants the entire island. Datu Cuevas, in his ignorance, declined the offer, preferring to accept an ornate gold shield, instead.

Two other colonies that were not penal colonies particularly intrigued me. One was a "colorum" colony off the western coast of Lake Mainit in Surigao and the other was Hilario Camino Moncado's colony (Filipino Federation of America, Inc.) at Dansalan. I visited the Moncado colony, where in the large modern administration building of tasteful appointments, I was requested to register in a large guest book. The yard decorations of the compound were unique. Moncado's huge statue in black academic robes was set on a pillar that bore on its sides the four marble slabs containing the doctor's complete biography. The statue is turned on a pivot, so that it always faces the sun. Noah's ark, with its "zoo" in stone, appears in vivid colors. The colony is unusual in that, not only is it vegetarian, but the food is eaten raw. Roots, nuts, and other eatables are merely cured in the sun, inasmuch as the heat of the sun is better, according to them, than any other source of heat for healthful cooking. Proof: The young men and young women members of the colony who received us were in the pinkest of condition.

I could not visit the "colorum" colony in Surigao, because only members had the privilege of entry to their hallowed grounds. It was said to be dangerous for outsiders to attempt it. The "colorum" colonists were once a turbulent, fanatical people that had given plenty of trouble to the authorities. A Constabulary lieutenant subdued them, not by force of arms, but by affiliating himself with them, and further elaborating their rites into a form that would arrogate to him superior authority. He then set himself at their head; he is known all over northern Mindanao as "Datu Tahid" (*tahid* meaning "spur", in allusion to his habit of being too prone to administer a good kick). The "colorum" colony is said to have developed a curious cult, with all the glamor and romance centering around the Datu, the like of which can only be expected to take root and attain rich flowering on the virgin soil of Mindanao.

ABSENCE OF TYPHOON

A giant nangca tree at Dansalan, fully ten meters high, standing in full vigor and loaded with fruits at the side of one of the streets, attests to the freedom of the place from destructive typhoons. The fruits, however, must be seriously menaced by fruitflies; but the Moros are careful to bag each nangca, in order to keep away the insects. The bags used were of woven palm leaves, the kind we call *bayong*.

At the Upi Agricultural School at Cotabato, a bamboo "log-cabin" was nearing completion. No nail was used; but the split half-canes, with their inner node-partitions partly protruding, were merely laid on. That building could not have lived through one rainy season here in Luzon!

But in Jolo, the delapidated Catholic church in the capital and the many dead teak (djati) trees over entire forests at Talipaw, were mute reminders of the freak typhoon that had laid this place low on May 1, 1932. Even typhoons, indeed, can sometimes turn *juramentado* when they happen to run astray into these Moro islands.

ACKNOWLEDGMENTS

The President of the University of the Philippines and the Dean of the College of Agriculture made the trip possible by kindly granting their permission to use this time for the project and securing funds for that purpose. Dr. Gonzalo Merino, chief of the division of plant pest and disease control, Bureau of Plant Industry, was a congenial and helpful travelling companion from Manila to Dansalan. Through his good offices, the co-operation of a number of the Bureau's inspectors stationed at various points of Mindanao was secured. Provincial Governors José Rosales of Agusan, Ubaldo Laya of Lanao, and James R. Fugate of Jolo and Division Superintendent of Schools Edward Kuder of Jolo generously helped in the way of automobile transportation and valuable information. The Ohta Development Company very graciously provided facilities for an extensive survey of the abacá plantations in Davao. Mr. Takeo Adzuma, in charge of the Company's experiment station, was good enough to act as personal host during that particular part of the investigation. Acting Governor Nicasio Valderrosa of Zamboanga kindly furnished letters of introduction to the deputy governors of Lamitan and Isabela de Basilan. Plant identifications were made by Dr. Eduardo Quisumbing, Dr. José B. Juliano, Dr. Felipe Salvoza, and Mr. Mamerto Sulit. For all these gentlemen, I wish to record my most profound gratitude.

CERTAIN BASES FOR PREDICTING SCHOLASTIC SUCCESS OF FRESHMEN IN THE COLLEGE OF AGRICULTURE [1, 2]

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A basis for predicting the scholastic success of a student in a chosen college course offers many advantages. It would eliminate disappointment of students and their parents; it would prevent waste of parents' and government money; it would save the time and effort of both the students and the faculty; and enable a school administrator to determine who should stay in his college and who should pursue a different career that would fit his mental capacity and personal traits. Since the demands upon the students differ in different colleges, each institution would have to determine the bases which might be used in predicting the probable success of its students, particularly the freshmen. The freshman year is usually the crucial point in a college career. The student's success in his first year usually determines whether he will continue or not. Those who succeed in the freshman year are usually the ones who attempt to pursue the course to completion.

Review of literature

The selection of students for higher education is not new. In the United States, institutions of higher learning have been using entrance examinations and accrediting systems previous to 1900. In that year, the College Entrance Examination Board was formed in order to standardize the examinations given to college applicants. The development of intelligence tests provided a new basis for determining the capacity of students to do college work. In recent years studies have been made in several institutions on the value of various criteria in predicting college success, the most common bases used being high school marks and scores made in intelligence tests.

MacPhail (1924) discussed the relative validity of different factors in predicting college success. He believed that the order of

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[1] Experiment Station contribution No. 1144. Received for publication September 2, 1936.

[2] The writer wishes to express his indebtedness to the Bureau of Education, and to Dr. Manuel L. Carreon in particular, for the privilege given him of using the mental ability and achievement tests prepared by the Bureau of Education.

validity of the different criteria used as measures of ability to do college work is: (1) intelligence examinations, (2) high-school marks, (3) comprehensive examinations, (4) content examinations, old type.

Odell (1927) found that in Illinois colleges and universities the coefficient of correlation between intelligence score and freshman success was 0.38; and between high school marks and success, 0.55.

Douglass (1931), at the University of Oregon, studied the relation to college success (average college mark in first two years) of average high-school mark, scores in a psychological examination, and school marks in certain high-school fields of study—English, history, mathematics, science, foreign languages. He obtained the following coefficients of correlation: general high-school average, 0.56; science, 0.54; English, 0.49; foreign languages, 0.46; mathematics, 0.44; social studies, 0.44; vocational studies, 0.36. The coefficient between intelligence test (percentile rank) and success was 0.45.

Douglass, in the same paper, summarized the findings of various investigators regarding the predictive value of high-school marks and intelligence-test scores. In different studies conducted from 1921 to 1930, high-school marks produced coefficients ranging from 0.29 to 0.77, or a median of 0.55. Of the studies conducted from 1920 to 1930 on the use of intelligence-test scores, the coefficients of correlation found ranged from 0.10 to 0.67, or a median of 0.45.

Edds and McCall (1933), of Milligan College, found that the coefficients of correlation between the average first-semester college mark and three criteria were: high-school average, 0.65; intelligence score, 0.50; English ability, as measured by a test, 0.44. The different groups of high-school subjects correlate with average college mark as follows: language, 0.66; vocational subjects, 0.62; mathematics, 0.60; English, 0.59; laboratory science, 0.52; and social science, 0.52.

Garrett (1934) determined the relation between senior high-school records and scholarship of students in Lousiana State University. He obtained the following coefficients based on four years of high-school marks: English, 0.69; mathematics, 0.68; social studies, 0.69; science, 0.67; languages, 0.56. He also found that there was a negligible difference between the predictive value of the four-year average marks and the average grade in the senior year or last two years of high school.

Most of these investigations included students pursuing various college careers in each of the universities studied and were not restricted to students of agriculture. A study which was confined to agriculture students was made by Edgerton and Toops in 1927 at the Ohio State University, where they found the correlation between high-school marks and college marks to be 0.37. In the Philippines no study has so far been made concerning the relation of various factors to the scholastic success of this group of students.

Object of the study

The object of this study was to determine whether certain factors, such as age, high-school grades, and performance in mental ability and schievement tests could be used as bases in predicting the scholastic success of freshman students in the College of Agriculture.

Method of study

In this study the 1932 and the 1934 freshmen were used. In 1932 the Philippine Mental Ability Test prepared by the Bureau of Education was administered to the freshmen. Their high-school grades in algebra, geometry, physics, English IV, economics, general history, biology and general science were also secured. In 1934 the same mental-ability test was also given to the freshmen. In addition, achievement tests prepared by the Bureau of Education in algebra, geometry, physics, English IV, biology and general science were administered. High-school grades of the students in these subjects were also obtained. Scores in the mental-ability test, achievement tests, and high-school grades were then correlated with the scholastic success.

The scholastic success of a student was expressed either in terms of his average grade during the year or the average grade-points. The method used in determining the average grade was as follows: The final grade in a subject was multiplied by the units it carried. The product was termed grade-units. The grade-units of a student in the different subjects were added, and the sum was divided by the total number of units. The quotient was his average grade. Since in the College of Agriculture the highest grade is *1* and the lowest is *5*, the average grade of a good student is a smaller figure than that of a poor student. In order that a positive relationship between scores, high school grades and scholastic success, may be expressed in a positive coefficient of correlation, another system of expressing scholastic success was employed; namely, in terms of average grade-points. A grade of *1* was given *5* points; a grade of *2*, 4 points, a grade of *3*, 3 points, a grade of *4*, 2 points, and a grade of *5*, 1 point. The highest grade-point a student could get was *5* and the lowest was *1*. The average grade-point earned by each student during the year was computed in the manner used in computing the average grade.

There were 156 students classified as freshmen in 1932. Included in this number were several students who were irregular freshmen. They registered in 1931 but failed in certain subjects. There were also several who were new but did not take the regular freshman courses. They were gradutes of agricultural high schools and had to take two or three high-school subjects in the U. P. Rural High School. Several students included in the freshman list dropped out before the end of the school year. Of the 156 only 96 could justifiably be included in the study. For the same reasons explained above, only 42 of the 70 students appearing in the freshman list in 1934 were included in the investigation.

RESULTS AND DISCUSSION

Relation between mental-ability test scores and scholarship of freshmen

The relation between scores of the 1932 freshmen in the Philippine Mental Ability Test and their average grade is shown in table 1. That for the 1934 freshmen may be seen in table 2. In 1932 the lowest score in the Philippine Mental Ability Test was 21; the highest was 86. In 1934, the lowest score was 33 and the highest was 83.

As shown in table 1, there is a positive relationship between the students' mental ability test score and average grade. As the scores increase, there is a corresponding improvement in the grades obtained. The difference is more pronounced in the groups with high scores. The group that averaged passing grade, 3.05, had a mental ability test score of from 60 to 69, or an average of 64.9. The group whose mental-ability test scores were from 70 to 79 received an average grade of 2.65. The group which made the highest score obtained an average grade of 2.05. It will be noted that the first three groups in table 1 had about the same average grade, although there was a wide difference in the mental ability test scores.

With the 1934 freshmen, the same relationship was found between the mental-ability test scores and average grade. In 1934, however, many groups made slightly better grades than the corresponding freshman groups in 1932. The average grades for the different groups were 3.69 in 1932 as against 3.49 in 1934; 3.67 as against 3.50, 3.41 as against 3.16, and 3.05 in 1932 as against 2.98 in 1934. In the two highest groups, on the other hand, the 1932 freshmen made better grades.

It is also shown in the last columns of tables 1 and 2 that those students with high mental-abilty test scores obtained higher grades in spite of the fact that they generally had a heavier load, but this does not imply that one may be able to improve his scholarship by increasing his load. It simply means that mentally capable students could be allowed to carry the maximum load and still be expected to get good grades.

The coefficient of correlation between mental-ability test scores and scholarship was 0.59 in 1932 and 0.61 in 1934, as shown in tables 3 and 4. These coefficients are higher than the 0.50 reported by Edds and McCall, 0.45 reported by Douglass, 0.38 reported by Odell, or the median coefficient of 0.45 obtained from studies summarized by Douglass. The higher coefficient obtained in the present investigation is probably due largely to the hemogeneity of the group studied. The group was composed of students taking the same courses under the same set of instructors. In studies conducted in other institutions, students pursuing different courses in different colleges were treated as one group. Naturally variation because of differences in difficulty of courses and standard of marking of different instructors would lower the coefficient.

Relation between grades in high-school subjects and scholastic success

The relation, in terms of coefficient of correlation, between the grades obtained by the students in certain high-school subjects and their scholastic success in freshman year is shown in tables 3 and 4. The coefficient of correlation between mental ability test scores, as well as age, and average grade-point is also shown. For the 1932 freshmen, the coefficient of correlation was determined between the high-school grades and the average grade-point. Whereas good grades in high-school subjects were represented by high percentages, the grades of good students in the College of Agriculture were represented by small numbers. In order to show positive coefficient of correlation for positive relationship, it was necessary to correlate high-school grades with average grade-point, instead of average grade.

It may be seen in table 3 that a positive correlation exists between grades in different school subjects and scholastic success. The same is true in the case of mental ability test scores and success. Of the different factors correlated with scholastic success, mental ability scores resulted in the highest coefficient, this being 0.59. This was followed by the mathematics courses: algebra, 0.49; physics, 0.46; geometry, 0.40. The other subjects gave the following coefficients: English IV, 0.36; biology, 0.35; economics, 0.31; and general history, 0.30. The coefficients in algebra, physics, and geometry compare favorably with those found by Douglass, but the coefficients in other subjects are much lower than those obtained by Douglass, Garrett, and Edds and McCall.

In table 4 are shown higher positive coefficients of correlation between grades in high-school subjects and scholastic success of the 1934 freshmen. It should be stated, however, that the coefficients between high-school grades and scholarship in 1932 are not comparable to those in 1934, since the coefficients were obtained from different sets of factors. In 1932, the two factors correlated were high-school grades expressed in percentages and freshmen success expressed in grade-points. In 1934, the majority of the high-school grades were reported on a five-point scale, such as 1, 2, 3, 4 and 5 or A, B, C, D and F. Hence in determining the coefficient in 1934 the two variables used were high-school grades expressed in number (1, 2, 3, etc.) and average grade in college. The close relationship that was found in 1932 between mathematical courses and success was again discovered in 1934. There was also an increase in the coefficient between scholarship and general science.

Relation between scores in achievement tests and scholarship

The coefficient of correlation between scores in achievement tests in certain high-school subjects and success (average grade-point) of the 1934 freshmen is shown in table 5. It will be seen that there is a positive relationship between the score that a student gets in an achievement test in algebra, physics, geometry, general science, biology or English IV and his success in freshman year in college. The highest coefficient was obtained between algebra and success, 0.63; followed by physics, 0.61; geometry, 0.58; general science, 0.53; biology, 0.51; and English IV, 0.47. These coefficients are as high as those obtained in other studies by the use of high-school grades.

The relation of age of students to freshman success

Age of the students, expressed in months, was found to have a negative correlation with freshman success. The coefficients, however, were very insignificant, being -0.06 in 1932 and -0.14 in 1934.

Comparison of the different bases studied

In table 6 is given a summary of the various coefficients of correlation obtained in this study. It appears that mental ability score ranks as high as any grade in a high-school subject or score in an achievement test. Using the average grade-point as the basis of success, one could see that mental ability test score has a closer relationship to success than the grade obtained in many high school subjects.

The scores in achievement tests in high-school subjects seem to be more closely associated with scholastic success (in terms of grade-point) than high-school grades. The coefficients shown in column 4 of table 6 are much higher than the corresponding coefficients in column 2. This should be expected. High-school grades of the students were given by different teachers in different high schools. It is a matter of common knowledge that the standards of grading used by different instructors in the same and in different institutions vary.

There seems to be no close agreement regarding the superiority of certain high-school subjects over others in predicting freshman success. Douglass obtained the highest coefficient between science and success, and the lowest between mathematics and success. On the other hand, Garrett, as well as Edds and McCall, found the lowest coefficient between science and success, and the highest between English or foreign language and success. In the present investigation, English produced one of the lowest coefficients. This lack of agreement might be due, to a certain extent, to the difference in the nature of the courses pursued in the freshman year in different institutions.

High coefficients were also obtained when high-school grades (expressed as 1, 2, 3, 4, 5) were correlated with average freshman grades in college, as may be seen in column 3. It was observed. however, that the majority of the students obtained the grade of *3* in their high-school subjects, and therefore, for purposes of prediction, high-school grades expressed as such have not as much value as when given in percentages. In the latter case there is a wider range of difference among students.

The ranking of the coefficients of correlation of the different subjects was practically the same when the high-school grades were correlated with success as when the achievement test scores were used. In both columns 2 and 4, one notices high coefficients of correlation in the mathematics courses, particularly algebra and physics.

SUMMARY

1. The scholastic success of freshman students in the College of Agriculture was found to be positively correlated with their Philippine Mental Ability Test score. The group that obtained higher test scores generally received higher grades, in spite of the fact that they usually carried a heavier load.

2. The group that obtained test scores of from 60 to 69 (average, 64.9) in 1932 got an average grade of passing, or 3.05. In 1934 those with scores of from 50 to 59 (average, 54.3) averaged nearly passing mark, or 3.16. This might have been due to more efforts exerted by the 1934 fresmen.

3. The Philippine Mental Ability Test scores were as closely associated with freshman success as the other factors studied. The coefficient of correlation obtained between mental-ability test scores and scholarship was 0.59 in 1932 and 0.61 in 1934.

4. Grades obtained in high-school subjects—algebra, physics, geometry, English IV, biology, economics, general history—were positively correlated with freshman success. In 1932 algebra registered the highest coefficient, 0.49, and physics next, 0.46.

5. Compared with the 1932 high school grades, the achievement-test scores obtained in 1934 in high-school subjects—algebra, geometry, general science, biology, English IV—produced higher coefficients of correlation with scholastic success. The highest coefficients were 0.63 for algebra, 0.61 for physics, and 0.58 for geometry. The ranking of the different subjects, however, remained practically the same, the mathematics courses showing higher coefficients.

6. Age had a very insignificant negative relationship with scholastic success, the coefficients of correlation being -0.06 in 1932 and -0.14 in 1934.

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TABLE 1

The relation between mental-ability test scores and scholastic success of 1932 freshmen

MENTAL ABILITY TEST SCORES	NUMBER OF STUDENTS	AVERAGE MENTAL ABILITY TEST SCORE	AVERAGE GRADE	NUMBER OF UNITS TAKEN
20–29	3	26.3	3.68	38.3
30–39	7	36.6	3.69	35.6
40–49	21	43.6	3.67	37.7
50–59	28	55.0	3.41	37.5
60–69	8	64.9	3.05	40.1
70–79	3	74.3	2.65	42.3
80–89	3	82.7	2.05	41.3

TABLE 2

The relation between mental-ability test scores and scholastic success of 1934 freshmen

MENTAL ABILITY TEST SCORES	NUMBER OF STUDENTS	AVERAGE MENTAL ABILITY TEST SCORE	AVERAGE GRADE	NUMBER OF UNITS TAKEN
30–39	6	35.8	3.49	37.0
40–49	9	45.0	3.50	36.4
50–59	11	54.3	3.16	36.4
60–69	6	66.5	2.98	37.0
70–79	8	74.9	2.83	40.2
80–89	2	82.0	2.21	44.0

TABLE 3

Coefficients of correlation between mental-ability test scores, age, grades in high-school subjects and scholastic success of 1932 freshmen

SCORES OF GRADES	r	P. E.
Mental-ability test scores	.59	.049
Algebra	.49	.052
Physics	.46	.059
Geometry	.40	.058
English IV	.36	.060
General science	.36	.065
Biology	.35	.062
Economics	.31	.064
General history	.30	.062
Age	—.06	.067

TABLE 4

Coefficient of correlation between mental-ability test scores, age, grades in high-school subjects and scholastic success[a] *of 1934 freshmen*

SCORES OF GRADES	r	P. E.
Mental-ability test scores	.61	.065
Algebra	.54	.076
General science	.65	.063
Physics	.65	.062
Geometry	.67	.060
English IV	.41	.090
Biology	.52	.079
Age	—.14	.104

[a] Scholastic success was expressed in terms of average grade.

TABLE 5

Coefficient of correlation between scores in achievement tests and scholastic success of 1934 freshmen

SCORES OF GRADES	r	P. E.
Mental-ability test scores	.61	.065
Algebra	.63	.064
Physics	.61	.069
Geometry	.58	.072
General science	.53	.076
Biology	.51	.078
English IV	.47	.084

TABLE 6

Summary of coefficient of correlation obtained between freshmen's success and various factors

FACTORS	GRADES IN HIGH-SCHOOL SUBJECTS		ACHIEVEMENT TEST SCORES, 1934 FRESHMEN
	1932 freshmen	1934 freshmen	
High school subjects:			
Algebra	.49	.54 [a]	.63
Physics	.46	.65 [a]	.61
Geometry	.40	.67 [a]	.58
General science	.36	.65 [a]	.53
Biology	.35	.52 [a]	.51
English IV	.36	.41 [a]	.47
Economics	.31	——	——
General history	.30	——	——
Other factors:			
Mental ability test score	.59	——	.61
Age	—.06	——	—.14

[a] Average grade was used in computing coefficient of correlation; in all others, average grade-point was employed.

STUDIES ON THE REPRODUCTIVE ORGANS OF THE MALE BERKJALA PIG, WITH SPECIAL REFERENCE TO SPERMATOGENESIS[1]

OSMUNDO MONDOÑEDO

WITH FIVE PLATES

Histological studies on the reproductive organs of the pig have not been carried out extensively, owing to the difficulty of preparing adequate specimens. With the development in the College of Agriculture of the Berkjala pig, now a fairly well established breed, materials for histological studies became available.

Time and place of work

The work here presented was started in January, 1932 and completed on February 10, 1934. The histological part of the work was conducted in the morphology laboratory of the Plant Physiology Department, under the direction of Dr. J. B. Juliano, and the macroscopic part in the Animal Husbandry Department of the College of Agriculture, University of the Philippines.

Object of the present work

The object of this work was to study the development of the male germ cells in the Berkjala pig with special reference to spermatogenesis.

MATERIALS AND METHODS

The materials used were 43 male Berkjala pigs of varying ages.

A portion of the testis taken from the pigs, just after birth, and at one, two, three weeks old, etc., up to seventeen weeks old were cut into very small pieces, teased and immediately fixed in the following solutions, (*a*) Bouin's fluid, (*b*) McClung's modification of Bouin's fluid, (*c*) Fleming's weak solution, and (*d*) Fleming's cold solution or modification of Hance's.

Bouin's fluid, as modified by McClung (1929), requires an addition to the original formula of 0.5 per cent urea. Urea is believed to increase the rate of penetration of the fixative. Before this fluid was used, four drops of 50 per cent chromic acid were added to every

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[1] Thesis presented for graduation, 1934 with the degree of Bachelor of Agriculture from the College of Agriculture No. 508; Experiment Station contribution No. 1147. Prepared in the Department of Animal Husbandry under the direction of Dr. Miguel Manresa.

10 cc. of the modified Bouin's. This fixing solution was found to be the most satisfactory.

The tissues were fixed for 24 to 36 hours, followed by two hours washing in running water. After washing, the tissues were dehydrated gradually in ascending strength of ethyl alcohol in percentages of 10, 20, 30, 40, 50, 60, 70, 80, 90 and 100, and finally transferred to xylene.

To insure complete paraffin infiltration, bits of soft paraffin were added from time to time till the saturation point was reached at room temperature and later at approximately 35 degrees Centigrade. The vials were then placed inside an oven at a temperature of 54°C., where all the soft paraffin melted. The remaining xylene was then washed off by three changes of melted soft paraffin. As soon as traces of xylene could no longer be detected, hard paraffin was used instead of soft paraffin. The hard paraffin was allowed to penetrate the tissues for six hours before imbedding.

Sections were cut at from three to ten micra with a rotary microtome. Mayer's albumin fixative was used to attach the sections to the slides. A slide warmer was used to stretch and dry the sections.

In most cases the stain used was Heidenhain's iron-alum haematoxylin. In some cases the slides were counter-stained with eosin (alcohol soluble). The mounting medium used was Canada balsam.

All drawings were made with the aid of a camera lucida. Photographs were taken with the aid of a photomicrographic camera.

RESULTS

Pigs, newly born. The testes of the newly born pigs were still inside the abdominal cavity. The testes could be taken out either by pressure or by killing the pigs. Upon examining a section of the testes under the microscope, the seminiferous tubules were found to be solid and convoluted. They measured 52.34 ± 0.37 micra in diameter (see table 3). The photomicrographs show the supporting tissue, the stroma, between the tubules.

The walls of the seminiferous tubules were composed of a layer of epithelial cells. Basal to the layer of these cells, outside the epithelial linings, were flattened cells supporting the seminiferous tubules. Within this layer was noted a large number of primordial germ cells. (Pl. 3, fig. 32). The primordial germ cells may be differentiated from the epithelial cells by their characteristic shape, size, reaction to stain, and number of nucleoli. The nucleus of the primordial germ cells were generally spherical and large, measuring

9.35 ± 0.06 micra in diameter (see table 2). They were slightly stained and each usually contained a nucleolus. On the other hand, the nucleus of the epithelial cells measured 6.02 ± 0.05 micra in diameter. In 64 cross sections of the seminiferous tubules examined, there were 298 large cells, the average number being 4.66 ± 0.11.

Inside the tubules was noticed a homogeneous mass seemingly of mucoid consistency.

Pigs, one week old. The testes of one-week old pigs were still inside the abdominal cavity. Sections of the testicles exhibited an increase in twisting and convolutions of the seminiferous tubules. Also, the tubules had slightly decreased in diameter, the average measurement being 46.64 ± 0.31 micra. (Pl. 3, fig. 27 and table 3).

The primordial germ cells were dividing mitotically. A decrease in the number of these cells was noted. In 64 cross sections of the tubules examined, there were a total of 134 large or primordial germ cells. Simultaneous with the decrease of these cells was a corresponding increase in the number of the small cells, next to the epithelial layer. From this increase it may be inferred that the primordial germ cells divided into small cells. These small cells were noted later on to develop into spermatogenia.

Intra-tubular vacuoles were seen in the slides examined. Some of the primordial germ cells, especially those about the center of the seminiferous tubules, showed signs of distortion. Whether the phenomenon was caused by fixation, as this portion of the tubule appeared less dense, could not be ascertained.

Pigs, two weeks old. Further decrease in the number of the primordial germ cells was noticed. Cross sections of 64 tubules gave a total count of 92 of these cells.

Greater vacuolation of the intra-tubular mass was noticed at this age.

The tubules had increased to 55.16 ± 0.32 micra in diameter; twisting was more marked. It was observed that the small cells, probably the early spermatogenia, further increased in number. Also, it was noticed that as early as this stage the epithelial cells showed signs of migration towards the center of the seminiferous tubules.

Pigs, three weeks old. At this age the testes were found entering the inguinal canal. The tubules had further increased to 64.84 ± 0.45 micra in diameter.

There was a further enlargement and convolution of the seminiferous tubules, which crowded out the stroma. A further decrease in the number of the large primordial germ cells was noted. The small cells, on the other hand, had greatly increased in number. A row of these cells was beginning to form next to the epithelial layer.

One outstanding feature of this stage was the denser appearance of the intra-tubular mass bordering the walls of the seminiferous tubules.

Pigs, four weeks old. At this stage the stroma was further crowded by increasing convolution and enlargement of the seminiferous tubules.

The large primordial germ cells had almost disappeared while a definite row of the small cells had formed on top of the original layer of epithelial cells.

Another important feature of this stage was the appearance of the first group of definitive spermatogonia (Pl. 4, fig. 35).

Pigs, five weeks old. The tubules showed a slight increase in size and convolutions, thus decreasing the area occupied by the stroma.

The large primordial germ cells could rarely be seen. On the other hand the spermatogonia were undergoing active mitosis.

Pigs, six weeks old. All the processes of the preceding stages continued; the spermatogonia exhibited all the phases of mitosis.

Pigs, seven weeks old. At seven weeks of age, part of the testis was still located in the inguinal canal. The seminiferous tubules had almost attained the degree of twisting which is characteristic of the pig approaching sexual maturity. The tubules had further increased to 71.88 ± 0.46 micra in diameter.

A section of the tubule revealed a very interesting feature. It chanced that a developing testis was caught on the verge of entering the second period of spermatogenesis, the spermatocytic stage. Large numbers of the spermatogonial cells were caught with distinct mitotic figures. Most of the cells showed the anaphase stages in mitosis, though occasional cells in the telophase were present.

Pigs, eight weeks old. At 8 weeks old the testes had descended into the scrotum.

Upon examining a portion of the seminiferous tubules, the presence of large primary spermatocytes especially of the prophase and metaphase stages was noted. Figure 36, plate 5, shows clearly the beginning of the spermatocytes. The basal rows of cells were similar to those of the preceding stage.

Pigs, nine weeks old. Tubules from nine weeks old pigs showed little difference from the preceding stage. The only feature of note was the increased mitotic activity of the spermatocytes. Cells in the anaphase stage were abundant. Whether this phenomenon was an anaphase of mitosis or meiosis could not be ascertained.

Pigs, ten weeks old. The tubules were found to be in marked activity. Figure 29, plate 3, shows the formation of considerable spaces which are devoid of nuclear or cellular structures at about the center of the seminiferous tubules, owing apparently to the germ cells collecting along the inner wall. Spermatocytes were very abundant. The spermatocytes exhibited the prophase, metaphase, anaphase and telophase stages, but no distinguishing difference in the reduction division could be noted from the previous stage.

Pigs, eleven weeks old. The most important feature of this stage was the enlargement of the cavities about the center of some of the seminiferous tubules. The tubules measured 92.42 ± 0.47 micra in diameter.

Resting spermatids were very abundant. Next to the spermatids ectal to the walls of the seminiferous tubules, were the spermatocytes caught at different phases of division. (Pl. 5, fig. 37).

Pigs, twelve weeks old. No noticeable change from the preceding stage.

Pigs, thirteen weeks old. At thirteen weeks, further formation of cavities at the center of the tubules was very marked. A large number of the seminiferous tubules was found with distinct cavities. Groups of spermatocytes and spermatids were seen detached from their original position, indicating migration of the germ cells.

Pigs, fourteen weeks old. There was further enlargement of the lumina by migration of cells towards the walls.

One animal of the same age exhibited a more advanced development of the testes, but this particular animal was herniated.

Pigs, fifteen weeks old. The testes show a marked progress in the development of the spermatozoa. Some tubules were still solid. A few of these solid tubules contained spermatozoa, and a large number exhibited all the stages of spermatogenesis.

Pigs, sixteen weeks old. Nearly all the cross sections examined bore spermatozoa. The tubules measured an average of 189.72 ± 1.06 micra in diameter. (Pl. 3, fig. 31).

DISCUSSION OF RESULTS

The testes

From birth to two weeks of age the testicles of all the pigs used were still held within the abdominal cavity. As the pigs grew older the testes descended through the inguinal canal into the scrotum. The passage through the inguinal canal occurred when the pig was between three to four weeks of age. At five weeks the formation of the scrotal sac was distinctly noted. The sac at first appeared to be a mere protrusion of the skin. The protrusion enlarged with age; at eight weeks of age it lodged the testes.

The tubules

Sections of the testes of newly-born pigs show a series of convoluted tubules running from the periphery to the mediastinum. When treated statistically, 64 cross sections of these tubules gave an average diameter of 52.34 ± 0.37 micra. At one week of age the diameter had decreased to 46.64 ± 0.31, probably to facilitate lengthening and greater convolution of the seminiferous tubules (Pl. 3, fig. 27 and 32). Hargitt (1926) reported the same phenomenon in the rat. Owing to the mitotic activity of the epithelial cells, a gradual increase in the size of the tubules was noted between the second to the eleventh week. At 16 weeks they measured 189.72 ± 1.06 micra in diameter. The radical increase in the diameter of the tubules from 92.42 ± 0.47 at 11 weeks of age may be attributed principally to the mechanical stretching of the walls, as shown by the flattened condition of the epithelial cells, which by this time, present no sign of mitotic activity. Simultaneous with the increase of the size of the tubules was the decrease of the intra-tubular area, or stroma (Pl. 3, fig. 27 to 31).

Twisting of the tubules at birth was not so pronounced, but the degree of convolution increased with age. At seven weeks it seemed that the maximum degree of convolution was reached.

Differentiation of the germinal and somatic cells

Sections of the seminiferous tubules of pigs just after birth revealed two types of cells; the large or primordial germ cells and the small epithelial cells. Later stages showed that these epithelial cells incidentally served as nurse cells.

These somatic cells were arranged in a row bordering the epithelial lining of the solid seminiferous tubules and were found to be held in position by flattened supporting cells of the stroma. They were very irregular in form, but most of them were ovoid with their blunt end ectal to the epithelial lining. The average diameter of these epithelial cells was found to be significantly smaller than that of the primordial germ cells; it being 6.02 ± 0.05 micra. They were deeply stained and contained one or more nucleoli. As age advanced some of them migrated towards the center of the seminiferous tubules, where they were occasionally seen between the spermatocytes and spermatids. Eventually, they formed the sertoli cells of the adult seminiferous tubules where the spermatozoa were found to be usually attached. Naturally, as age advanced the layer of epithelial cells became less and less defined.

About the center of the seminiferous tubules of pigs just after birth, within the layer of epithelial cells was noted a large number of primordial germ cells. They measured 9.35 ± 0.06 micra in diameter. Statistical treatment of the number of large cells showed an average of 4.66 ± 0.11 of these cells per cross section of the seminiferous tubules. The total number of sections examined was 64.

At one week of age the number of large cells had decreased to 2.09 ± 0.08. Further decrease was noted; at two weeks, 1.44 ± 0.07; and at three weeks, 0.69 ± 0.06. In all these ages, different stages of mitosis of the large cells were seen. As a corresponding increase of the number of small cells was noted, it may be inferred that the large cells divided into smaller cells.

At four weeks of age the number of large cells had increased from 0.69 ± 0.06 to 1.84 ± 0.08. It seemed that the large primordial germ cells had increased in number. Upon measuring, however, the size of the large cells it was found that they were significantly smaller than the large primordial germ cells. Comparing them with the spermatogonia in mature pigs, no significant difference was noted (see table 2). Coincident with the increase in the number of these cells was the appearance of the definitive spermatogonia of the metaphase stage. It is probable that these cells appearing at four weeks of age were the resting definitive spermatogonia.

Table 1 shows, that the coefficient of variation of the number of large cells in a cross-sectional area of each tubule increased very significantly up to three weeks of age. After the third week a gradual decrease was noted. From this curve it may be inferred that the most active transformation and development of the germ cells occurred at three weeks of age, while the preparatory period from birth to this time was marked by a relatively much more gradual change. Likewise, the period between the third and the sixteenth week showed no sign of markedly active development.

Further increase in the number of spermatogonia was noted in pigs five, six and seven weeks of age (see table 1).

At eight weeks no counts were made owing to the introduction of a third factor, the appearance of the spermatocytes.

Development of the lumina

The seminiferous tubules of pigs just after birth were composed of a layer of epithelial cells. Within this layer was noted a large number of primordial germ cells held in suspension by a homogeneous mass, probably of mucoid consistency. As age advanced this uniformly dense intra-tubular mass became drawn toward the walls until at 11 weeks distinct cavities were formed.

Upon examining sections of the seminiferous tubules of adult pigs, it was noticed that a large number of spermatids were close to the epithelial wall. In other words, no definite layer of spermatogonia, spermatocytes or spermatids could be discerned. It can then be inferred that the formation of cavities in the lumina is caused by the migration of germ cells toward the walls of the seminiferous tubules (Pl. 5, fig. 38).

Hargitt (1926) attributed the formation of these cavities to the degeneration of spermatocytes and spermatids. In these materials, distortion of a few of these cells was noted. Whether this phenomenon was caused by fixation could not be ascertained. In the development of the spermatozoa, however, it is quite likely that the disappearance of a part of the cytoplasmic mass left behind degenerated because of absorption.

Spermatogenesis

Primordial germ cells. The undifferentiated large cells bordering the walls of the seminiferous tubules of the newly-born pigs, probably, were the potential spermatogonia.

In the mature specimens of the pigs, there were no indications by which one could deduce whether the small and the large cells were of different generations. In specimens obtained from immature pigs, however, the resting stage of the primordial germ cells found at birth was larger than the definitive spermatogonia found at four weeks of age. From this it may be inferred that the large cells were earlier in generation (older). Masui (1923) reported a similar occurrence in the mature mouse and rabbit.

The resting nucleus of the primordial germ cells usually contains a nucleolus and several chromatin granules lying on the linin threads (Pl. 1, fig. 1). The chromatin masses, including the nucleolus, align to form the spireme (Pl. 1, fig. 2). The spireme, later on, becomes denser and elongated, covering almost the entire area of the nucleus (Pl. 1, fig. 3). No definite metaphase stage was noted; however, a cell of the late anaphase was seen as shown in plate 1, figure 4.

Pigs one to two weeks old showed the same mitotic activity. This activity denotes more than one generation of the early spermatogonia.

Definitive spermatogonia. At four weeks old, the first group of definitive spermatogonia was noted. The resting nucleus appeared to be similar to those of the resting primordial germ cells, but with more defined granules and linin threads (Pl. 1, fig. 6). The nucleus was also significantly smaller than that of the resting primordial germ cells (see table 2). The chromatin masses of the spermatogonial resting stage converged and formed a thick granulated spireme which later became elongated (Pl. 1, fig. 7). After sufficient condensation, straightening and equalization in thickness, the spireme segmented into 40 pieces, representing the diploid number of chromosomes (Pl. 1, fig. 8).

At seven weeks old the spermatogonial chromosomes formed a row at the equatorial regions. The spindle fibers were seen attached to the ends of short rod-shaped chromosomes, and at the same time the nuclear membrane disappeared. The chromosomes then migrated to their respective poles, and thus terminated the spermatogonial cycle (Pl. 1, fig. 9 and 10).

Spermatocytes. (*1*) *Maturation.* (*a*) Resting spermatocytes. After the telophase stage of the spermatogonia, the thick chromatin mass reorganizes, forming the resting stage of the spermatocytes. This stage was attained at 8 weeks of age. The resting stage of the spermatocyte was similar to those of the spermatogonia, but very much larger. The spermatocytes were found to be 9.53 ± 0.05 micra in diameter as against the spermatogonia of 8.04 ± 0.05 (Pl. 1, fig. 11). (*b*) *Leptotene stage.* The chromatin masses, which condensed and elongated, formed the spireme. The spireme was made up of a single thread with bead-like structure at its different portions. These bead-like forming structures are called chromomeres (Pl. 1, fig. 12).

A few of the spireme exhibited a slight aggregation at one side of the nucleus. Moreover, these cells were located at the inner part of the tissue which the fixative, probably, had not reached in time to prevent contraction of the nuclear content. (Pl. 1, fig. 13).

Hance (1719a) denied the occurrence of synizesis in mammalian tissue. He stated, "Synizesis is not seen in this material except in the center of a piece of tissue, which was rather larger, and where the fixative had not penetrated." Darlington (1923) considers synizesis an artifact. Contrary to these cases, Masui (1919) in the horse and later (1923) in the mouse and rabbit, Wodsedalek (1913) in the pig, Jordan (912) in the opossum, and Buchner (1910) reported synizesis.

Zygotene stage. The spireme occurred in double threads as indicated by their thickness. They appeared double the diameter of the leptotene stage and in some instances actual parallelism of the conjugate spireme was seen (Pl. 1, fig. 14).

Pachytene and diplotene stages. The paired threads seemed to contract as indicated by their decreased length and increased diameter in later stages. Eventually, they become very thick and short, and consequently destroyed the continuity of the threads. During their maximum longitudinal contraction or at diakinesis, the chromosomes occurred in pairs (Pl. 2, fig. 15). These bivalent chromosomes represent the haploid or reduced number.

The heterotypic division. At the metaphase stage, pairing of chromosomes was seen. Some showed circular formations, but a great majority were U-shaped in form. Hance (1917b) reports similar occurrence in the pigs. He stated, when chromosomes are arranged side by side according to length, they form a series which falls gradually from long end to short end of the series. In such a series chromosomes align in pairs.

At the anaphase stage the paired chromosomes are separated by constriction.

An evidence of lagging of chromosomes during the anaphase stage was noted. Some pairs of chromosomes showed such affinity for each other that separation was attained only after much prolonged elongation and constriction. This phenomenon probably indicates the occurrence of chiasma or crossing over.

The homoeotypic division. It is likely that the second resting stage (interphase) of the spermatocytes was only of short duration. A second probability is that it could not be distinguished from the resting stage preceding it. The second metaphase showed that reduction must have taken place as the number of chromosomes was haploid (Pl. 2, fig. 17). Pairing of chromosomes was not seen. At the telophase the chromosome distribution was that of an ordinary mitosis. (Pl. 2, fig. 18).

Spermatids. At eleven-weeks the final telophase stage of the spermatocytes gave rise to the resting spermatids, which appeared very much reduced in size. The diameter was found to be 5.55 ±

0.03 micra. The resting spermatids usually contain a few chromatin masses and granules. (Pl. 2, fig. 19).

Formation of the spermatozoa. A dark cytoplasmic body (centrosome) went to the portion of the nucleus destined to be the posterior end (Pl. 1, fig. 20). Another mass (acrosome) converged at the anterior end while the nucleus exhibited a simultaneous axial elongation forming a pear-shaped body (Pl. 2, fig. 21). An axial filament began to form out of the cytoplasmic body, that previously migrated posteriorly (Pl. 2, fig. 22). With the further elongation and outward movement of the spermatozoa the cytoplasmic mass containing granules was left behind, forming a pair of rudimentary filaments which may be mistaken for a second and third tail (Pl. 2, fig. 23). These remnants disappeared in the later stages (Pl. 2, fig. 24). It is quite likely that the granules left with the cytoplasmic mass adhered to the middle piece of the spermatozoa. The first crop of mature spermatozoa was noted at 15 weeks, but some of the seminiferous tubules were still of solid cords. The opening of the tubules at 16 weeks probably denoted complete maturity.

SUMMARY AND CONCLUSIONS

1. At birth the testes were held within the abdominal cavity; at three weeks they entered the inguinal canal; and at eight weeks they were lodged in the scrotal sac.
2. The seminiferous tubules increased in size and convolution with age. The cavities in the lumina were formed by migration of the germ cells toward the wall.
3. The large primordial germ cells divided first into smaller cells before giving rise to the spermatogonia.
4. The first group of definitive spermatogonia began to form four weeks after birth, spermatocytes appeared on the eighth week, spermatids on the 11th week and spermatozoa at the fifteenth week.
5. Sexual maturity was complete sixteen weeks after birth.

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ILLUSTRATIONS

Figures 1 to 26 of plates 1 and 2 were drawn with the aid of a camera lucida at a magnification of × 3,035.

Figures 27 to 39 of plates 3, 4, and 5 are photomicrographs. Figures 27 to 31 of plate 3 were taken at a magnification of ×93, exposed for one-half second. Figures 32 to 39 of plates 3, 4, and 5 were taken at a magnification of × 400, exposed two and one-half seconds. In both cases a tungsten lamp, without filter, was used for illumination.

PLATE 1

Primordial germ cells

Fig. 1. Resting stage
2 and 3. Spiremes
4. Late anaphase
5. Telophase

Definitive spermatogonia

6. Resting stage
7. Spireme
8. Metaphase showing 40 chromosomes
9. Anaphase
10. Telophase

Spermatocytes

11. Resting stage
12. Leptotene stage showing single spireme thread
13. Synizesis
14. Zygotene

PLATE 2

Spermatocytes (continued)

Fig. 15. Pachytene and diplotene showing segmentation by contraction of the spireme thread.
16. Anaphase of meiosis
17. Metaphase of the second reduction division showing 20 chromosomes
18. Anaphase of the second reduction division

Spermatids up to the formation of the spermatozoa

19. Resting spermatids
20. Nucleus showing centrosome and acrosome
21. Elongated nucleus
22. Formation of the axial filament leaving the cytoplasmic mass behind
23. Young spermatozoa showing pairs of rudimentary filaments that may be mistaken for a second and third tail.
24. Spermatozoa showing absence of the rudiments
25-26. Mature spermatozoa

PLATE 3

Section of the testes at different ages

Fig. 27. One-week old pigs, magnification × 93
28. Seven-week old pigs, magnification × 93
29. Ten-week old pigs, magnification × 93
30. Eleven-week old pigs, magnification × 93
31. Sixteen-week old pigs, magnification × 93
32. At birth, magnification × 400
33. At one-week of age, magnification × 400

PLATE 4

Sections of the testes at different ages taken at magnification × 400

Fig. 34. Two-week old pigs.
35. Four-week old pigs

PLATE 5

Sections of the testes at magnification × 400

Fig. 36. Eight-week old pigs
37. Eleven-week old pigs
38. Fifteen-week old pigs
39. Sixteen-week old pigs

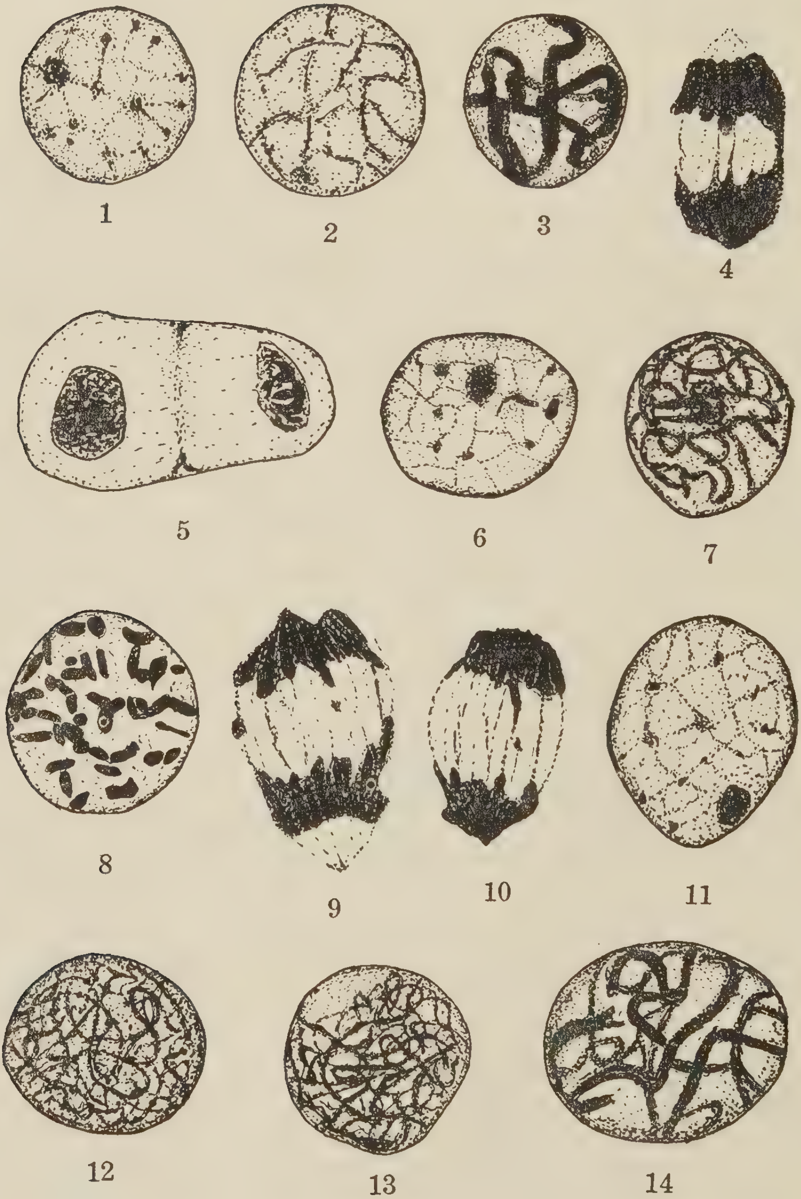
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PLATE 1

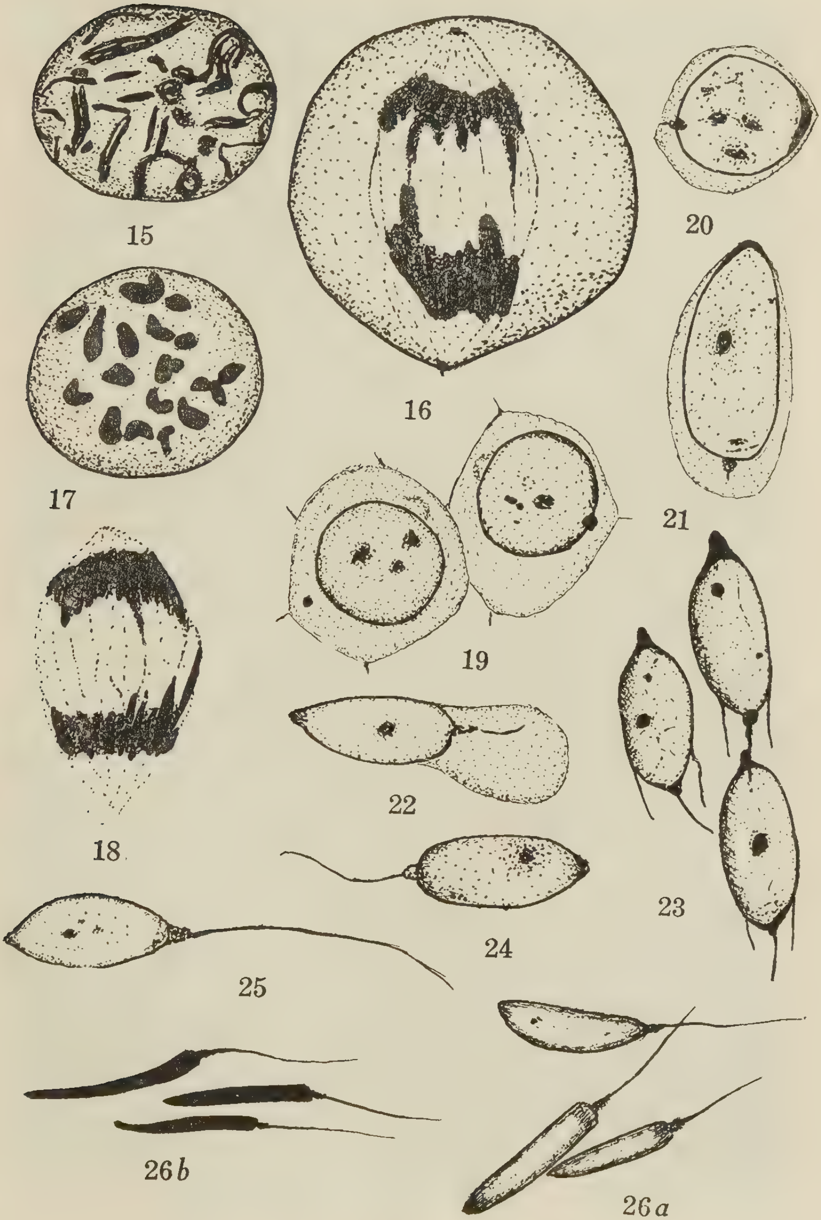
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PLATE 2

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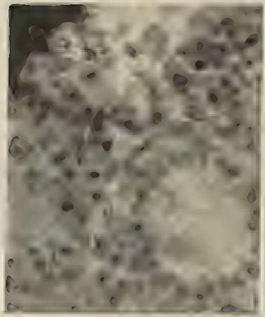
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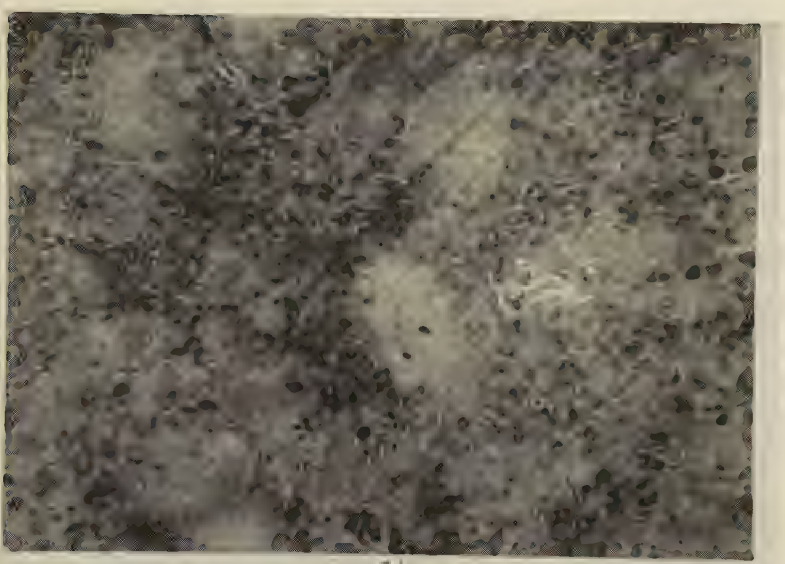
PLATE 3



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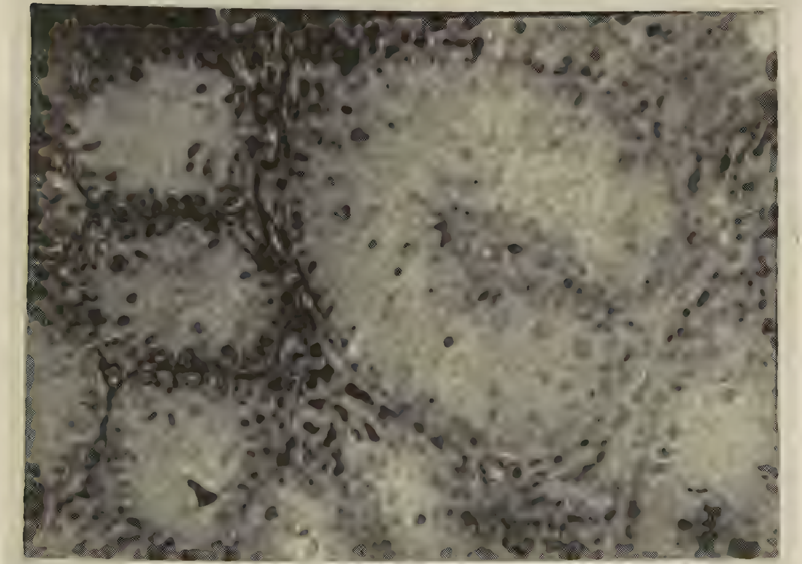

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Plate 4

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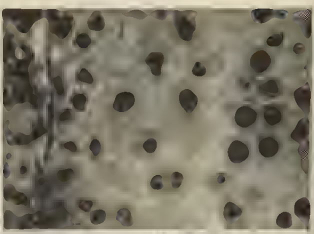

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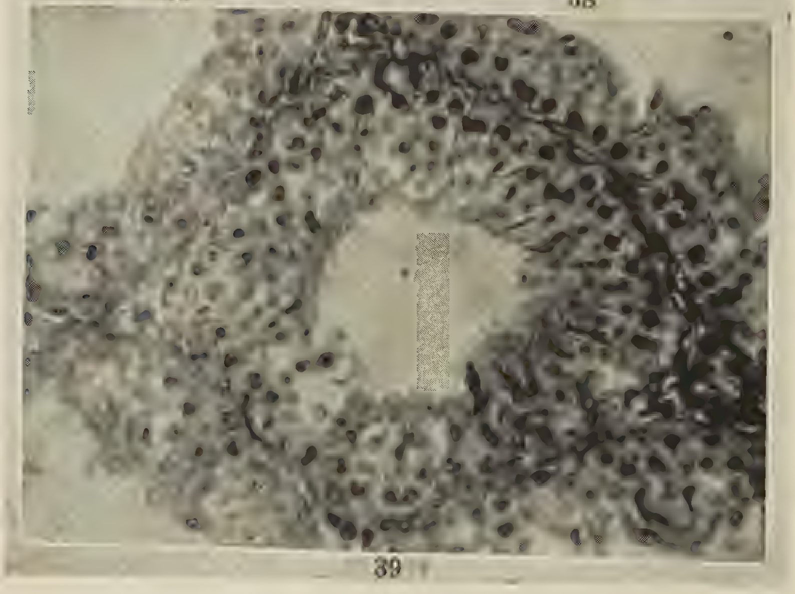

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PLATE 5

TABLE 1

Showing the relative number of large cells in a cross-sectional area of each tubule at different ages

AGES	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIABILITY
	μ	μ	*per cent*
At birth	4.66 ± 0.11	1.34 ± 0.08	28.75 ± 1.71
One-week old pigs ..	2.09 ± 0.08	0.95 ± 0.06	45.45 ± 2.70
Two-week old pigs ..	1.44 ± 0.07	0.84 ± 0.05	58.33 ± 3.47
Three-week old pigs .	0.69 ± 0.06	0.77 ± 0.05	112.59 ± 6.71
Four-week old pigs .	1.84 ± 0.08	0.94 ± 0.06	51.08 ± 3.04
Five-week old pigs .	3.45 ± 0.15	1.32 ± 0.08	38.26 ± 2.28
Six-week old pigs ..	8.44 ± 0.13	1.52 ± 0.09	18.03 ± 1.07
Seven-week old pigs .	8.62 ± 0.11	1.33 ± 0.08	15.43 ± 0.92

TABLE 2

Showing sizes of germ cells (diameter in micra)

GERM CELLS	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIABILITY
	μ	μ	*per cent*
Primordial germ cells	9.35 ± 0.06	0.75 ± 0.04	8.02 ± 0.47
Spermatogonia (in four-week pig) ..	8.04 ± 0.05	0.65 ± 0.04	8.08 ± 0.48
Spermatogonia (mature)	7.95 ± 0.06	0.71 ± 0.04	8.93 ± 0.53
Spermatocytes	9.53 ± 0.05	0.64 ± 0.04	6.71 ± 0.40
Spermatids	5.55 ± 0.03	0.39 ± 0.02	7.05 ± 0.41

TABLE 3

Showing the diameters in micra of the seminiferous tubules at different ages

AGES	MEAN	STANDARD DEVIATION	COEFFICIENT OF VARIABILITY
	μ	μ	*per cent*
At birth	52.34 ± 0.37	4.40 ± 0.26	8.40 ± 0.50
One-week old pigs ..	46.64 ± 0.31	3.65 ± 0.32	7.83 ± 0.47
Two-week old pigs .	55.16 ± 0.32	3.85 ± 0.23	6.98 ± 0.42
Three-week old pigs .	64.84 ± 0.45	5.30 ± 0.32	8.28 ± 0.49
Seven-week old pigs .	71.88 ± 0.46	5.49 ± 0.33	7.64 ± 0.46
Eleven-week old pigs	92.42 ± 0.47	5.58 ± 0.33	6.03 ± 0.36
Mature (16-weeks) .	189.72 ± 1.06	12.61 ± 0.75	6.65 ± 0.40

THE EFFECTS UPON THE YIELDS OF CANE AND SUGAR OF REMOVING THE ARROWS OF SUGAR CANE[1]

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Arrowing or tasseling is a distinct character of certain varieties of sugar cane. Although arrowing is an important factor in the production of cane seedling varieties, it is believed that arrowing reduces the tonnage and sucrose content of the cane. Since in the Philippines most of the high yielding varieties of sugar cane arrow freely, it will be of interest to find out if the yield of these varieties could be improved by removing the arrow.

Review of literature

The effects of arrowing upon the weight and composition of sugar cane have been studied in various countries. In Hawaii, Alexander (1923) found that H-109 which had recently arrowed had higher sugar content than those that had not arrowed. However, when the canes grown under unirrigated conditions were analyzed several months after arrowing, the reverse seemed to be true. He also found that with D-1135 there was a little difference in favor of the non-arrowed canes.

According to Grobert (1921) in Peru, Labarthe observed that the canes with flowers had relatively poorer sucrose and richer glucose content than those without flowers. It was further observed that after arrowing, the canes had less juice and there was a decrease in the weight of the crop; and, as a whole, the weight of the sugar was very small.

Venkatraman (1923) working on the same subject in India, points out that the harm from flowering results chiefly from the stoppage of growth in the main shoot, the sprouting of buds immediately below and a pith developed in the center by the flowered canes, conditions that lower the tonnage.

Ghosh (1926) found that there is no indication of any decrease of weight in the crop caused by flowering nor of any perceptible diminution in the quantity of juice yield. He found that the flowering of sugar cane is not necessarily detrimental to the yield of sugar.

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[1] Experiment Station contribution No. 1146. Received for publication July 27, 1936.

According to Earl (1921), in Porto Rico, flowering canes are not looked upon with favor for they are believed to yield less juice which is richer in glucose. He ascribed this to the fact that arrowing frequently takes place sometime before harvest when, in the event of rain moistening the soil, shooting takes place with deterioration of sugar content of arrowed canes.

Geerligs (1927) reported that arrowing of cane is disadvantageous because vegetative growth ceases, and the canes are more likely to deteriorate than when they had not arrowed. However, he believed that arrowing does not alter the composition of the cane to any extent.

It appears from the available literature that no work similar to the present study has been conducted in other countries.

In the College of Agriculture, studies similar to the present one were conducted by Sabalburo (1933). He found that detasseling had an insignificant effect upon the apparent purity of the juice of sugar cane. He also found that in some varieties of sugar cane studied there was a negligible difference in the weight of detasseled and undetasseled stalks. However, he found that in P. B. 536 and Uba de Natal, the difference which was in favor of the undetasseled canes was significant.

Objects of the present study

The objects of the present work were: (a) to determine the effects of removing the arrow of sugar cane upon the production and development of "lalas", and (b) to determine the effects of removing the arrow of sugar cane upon the yields of cane, sugar and piculs sugar per ton cane.

Time and place of the present work

The work was conducted from October, 1934 to March, 1936 in the Experiment Station field of the College of Agriculture.

MATERIALS AND METHODS

Field and variety of sugar cane used. The soil is clay loam. The field was divided into several plots with areas ranging from 502.2 to 518.4 square meters.

Two high yielding commercial varieties of sugar cane namely P.S.A. 7 and POJ 2878 were used. Three other flowering College seedling varieties of sugar cane under commercial test were also used. These seedling varieties were C.A.C. 117, C.A.C. 126, and C.A.C. 128. With the exception of P.S.A. 7, each variety was planted in four plots. There were only two replications in P.S.A. 7.

Preparation of the land and planting. The land was plowed and harrowed several times before the seed pieces of sugar cane were planted.

The seed pieces were soaked for 24 to 48 hours in running water before they were planted. The furrows were 100 cm. apart and the seed pieces were planted 40 cm. apart in the furrow.

Fertilization. Ammonium sulfate was used for fertilizing the sugar cane. It was broadcasted in the furrows at the rate of 375 kgm. per hectare just before planting.

Cultivation. The canes were cultivated in the usual manner by using a native plow. The cultivation was an alternate off-barring and hilling-up. Weeding with native hoe was done once. The last cultivation was hilling-up or closing-in.

Determination of percentages of germination and stand of plants. The percentage of germination of the seed pieces in each plot was determined. Likewise, the percentage of stand of plants in each plot was determined by going over the rows and recording the number of living hills in the rows of the different plots.

Observation on external signs of arrowing and determination of percentage of arrowing. The four stages of arrowing were noted; namely, boenting, flag, shooting, and opening stages. The percentage of arrowing in each plot was determined by counting 100 stools at random and recording the number of stools that had arrowed.

Detasseling or removing the arrows. To determine the effects of removing the arrows upon the production and the development of "lalas" [2] and yields of cane and sugar of sugar cane, the plots planted to the different varieties of sugar cane were each divided into two lots. Detasseling was made on alternate lots; the undetasseled lots served as control.

A preliminary experiment was conducted to determine at what stage of flowering was the best time to cut off the arrow entirely such that no eye or bud was included in the severed portion of the stalk. It was found that the best stage to cut the arrow was at either the opening stage or at full emergence. Detasseling was therefore begun when some of the canes had their arrows at full emergence. Subsequent removal of the arrow was done twice a week until all the arrows in a lot were removed. It usually took another week to remove the arrows of the rest of the flowering canes. Only canes that had their arrows at the opening stage or at full emergence were detasseled.

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[2] In flowering varieties of sugar cane as POJ 2878, during flowering, the eyes or buds at the upper nodes sprout and grow into short-jointed very woody side shoots containing numerous eyes. These side shoots are locally known in Hawaii as "lalas." With the cultivation of the flowering varieties of sugar cane in the Philippines, the word is coming into use in this country.

Observation of effects of detasseling upon production and development of "lalas". Observations were made on the development of "lalas" after removing the arrows. At maturity or at the time of harvesting 25 representative stalks from each of the detasseled and control lots were cut and examined. The number of "lalas" produced per stool and the length of each "lala" were recorded.

Harvesting and determination of yields. The canes were harvested from Feb. 5 to March 11, 1935 or about 12 to 13 months after planting. They were harvested, weighed and analyzed separately. The canes were milled in the U. P. Sugar Mill. A composite sample of the crusher juice from each treatment was analyzed and the degree Brix and percentage of polarization were determined with the help of Dr. Getulio Guanzon of the Agricultural Chemistry Department. From these data the apparent purity, piculs sugar per ton cane and piculs sugar per hectare of each treatment were determined by the use of *Methods of Chemical Control for Cane Sugar Factories* published in 1931 by the Association of the Hawaiian Sugar Technologists.

RESULTS AND DISCUSSIONS

The results of this study are presented in tables 1 to 6.

Percentages of germination and stand of plants. Table 1 shows the percentages of germination and stand of plants of the different varieties of sugar cane studied. It will be seen in this table that the average percentage of germination of the different varieties ranged from 58.99 to 67.83. The percentage of stand of plants of the different varieties ranged from 58.09 to 67.19. This table shows that only a few plants died after the seed pieces had germinated.

Observations on external signs of arrowing and percentage of arrowing. The following four stages of arrowing as observed by Sabalburo (1933) were also noted.

Boenting stage. At this stage, the highest leaf sheath begins to elongate and the leaf blade begins to shorten.

Flag stage. At the flag stage, the last leaf takes a slightly inclined to a vertical position.

Shooting stage. The shooting stage is observed at the moment the tip of the arrows begins to appear.

Opening stage. At the opening stage the pistils and stamens appear.

The different varieties exhibited these various stages at different times. On October 14, 1934, some of POJ 2878 canes were at the boenting and shooting stages, and a week later or on October 21, 1935, detasseling of this variety began. On November 12, 1935, some of the stalks of C.A.C. 117 and C.A.C. 126 were at the boenting and shooting stages. On this same date most of the stalks of C.A.C. 128 were at the shooting stage. Detasseling of the other varieties began as follows: C.A.C. 128, November 18; C.A.C. 117, November 19; C.A.C. 126, November 29; and P.S.A. 7, December 12, 1935. According to these observations the different varieties tasseled in the order of their earliness as follows: POJ 2878, C.A.C. 128, C.A.C. 117, C.A.C. 126, and P.S.A. 7.

It will be seen in table 2 that the different varieties exhibited different degrees of tasseling. The average percentage of tasseling in the descending order was as follows: C.A.C. 128, with 96.75; POJ 2878, with 88.5; C.A.C. 117, with 69; C.A.C. 126 with 66 and P.S.A. 7 with 47 per cent.

Effect of detasseling upon the production and development of "lalas". The "lalas" were already observed at the time the canes were detasseled. In fact some of the stalks began to produce "lalas" at the time the first stage of arrowing was noticed. In table 3 may be seen the comparative number of "lalas" and length of "lalas" of detasseled and non-detasseled canes.

It will be seen in this table that with the exception of C.A.C. 128, detasseling increased the number of "lalas" produced by all the varieties studied. In C.A.C. 128, the control produced 0.32 ± 0.2352 more "lalas" than the detasseled stalks, which is an insignificant difference. The detasseled stalks of C.A.C. 117, C.A.C. 126, and P.S.A. 7, produced significantly more "lalas" than the control. These three varieties flowered slightly and late. The difference in the number of "lalas" produced by the detasseled and control stalks of C.A.C. 128 and POJ 2878 was negligible. This may be due to the fact that these two varieties flowered early and profusely.

The results shown in table 3 indicate that detasseling has no definite effect upon the length of the "lalas" produced. It will thus be seen in this table that there was an insignificant difference in the average length of the "lalas" produced by the detasseled and control stalks of C.A.C. 128 and P.S.A. 7 and no difference in POJ 2878. Furthermore, whereas the detasseled stalks of C.A.C. 117 produced significantly longer "lalas" than the control; in C.A.C. 126, the control produced significantly longer "lalas" than the detasseled ones.

Effect of detasseling upon the yield of cane. The effect of removing the arrow upon the yield of cane is shown in table 4. It will be seen in this table that the detasseled stalks of C.A.C. 117, C.A.C. 126, P.S.A. 7 and POJ 2878 produced more canes per hectare than the control. However, the differences are insignificant. In the case of C.A.C. 128, the control gave more cane per hectare and the difference is also negligible. These results indicate that removing the arrows of sugar cane does not affect the weight or tonnage of canes produced. These results agree with the findings of Sabalburo (1933) who reported that the differences in weights between the detasseled stalks and the control of POJ 2727, C.A.C. 87, Hind's Special and Badila were insignificant.

Effect of detasseling upon the purity of the juice. The effect of removing the arrow upon the purity of the juice of sugar cane is shown in table 5. It will be seen in this table that the detasseled stalks of C.A.C. 128, POJ 2878 and P.S.A. 7 had slightly higher purity of juice than those of the control, but the differences are insignificant. On the other hand it will be noted that the detasseled stalks of C.A.C. 117 and C.A.C. 126 had insignificantly lower purity of juice than those of the control. These results show that detasseling does not affect the purity of the juice of sugar cane. These results verify the findings of Sabalburo (1933) who found that detasseling had an insignificant effect upon the apparent purity of juice of C.A.C. 87, Hind's Special, P.B. 536, Badila, POJ 2727 and Uba de Natal.

Effects of detasseling upon the yields of sugar per hectare and piculs sugar per ton cane. The effects of removing the arrow upon the yields of sugar and piculs sugar per ton cane are shown in table 6. It will be seen in this table that the detasseled stalks of C.A.C. 117, C.A.C. 126, POJ 2878, and P.S.A. 7 produced more sugar per hectare than the control but the differences are statistically insignificant. On the other hand the detasseled stalks of C.A.C. 128, produced less sugar per hectare than the control and the difference is insignificant. These results indicate that removing the arrow of sugar cane does not have any effect upon the yield of sugar.

It may be seen in table 6 that the detasseled stalks of C.A.C. 117, and C.A.C. 126 produced less piculs sugar per ton cane than the control; in C.A.C. 126, the difference is slightly significant and in C.A.C. 117, the difference is insignificant. The detasseled stalks of C.A.C. 128, POJ 2878, and P.S.A. 7 produced more piculs sugar per ton cane than the control and the differences are insignificant. These results seem to indicate that removing the arrow of sugar cane does not affect the yield of piculs sugar per ton cane. These results also agree with the findings of Sabalburo (1933) who reported that the difference in piculs sugar per ton cane of the control and detasseled stalks of POJ 2727 was insignificant.

As a whole the results show that removing the arrow of sugar cane does not have any effect upon the yields of cane and sugar of sugar cane. The probable explanation for these results is the fact that flowering results in the stoppage or ceasation of growth of the main shoot. In fact the only change noted after flowering was the production of "lalas", and those "lalas" were noted whether the cane was detasseled or not.

Detasseling is disadvantageous. There were many difficulties encountered in removing the arrows of sugar cane. The canes were criss-crossed and it was hard to go through the rows during detasseling. Many of the stalks were damaged or broken when the criss-crossed canes were stepped on. Some of the stalks were broken also when the tall stalks were bent to remove the arrows. Inasmuch as removing the arrow of sugar cane does not improve the yields of cane and sugar, that it damages some stalks and that an extra cost of labor of removing them is incurred, this operation is therefore considered disadvantageous.

SUMMARY AND CONCLUSIONS

An attempt was made to study the effects of removing the arrow of sugar cane upon the yields of cane and sugar. The results obtained from this study may be summarized as follows:

1. The "lalas" developed on cane stalks of all varieties studied, whether the arrows were removed or not. Detasseling seemed to increase the number of "lalas" produced by late and slightly flowering varieties of sugar cane; but it did not seem to have any effect upon the early and profusely flowering varieties. The length of "lalas" produced was not affected by removing the arrow of sugar cane.

2. The apparent purity of the juice was not affected by removing the arrow of sugar cane.

3. The yield of cane was not affected by removing the arrow of sugar cane.

4. The yields of sugar per hectare and piculs sugar per ton cane were not affected by removing the arrow of sugar cane.

5. Removing the arrow of sugar cane was laborious and many stalks were broken during the operation.

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TABLE 1

Percentages of germination and stand of plants of different varieties of sugar cane

VARIETY	PLOT	GERMINATION	STAND
	number	*per cent*	*per cent*
C.A.C. 117	1	43.12	42.18
	2	71.05	70.17
	3	79.39	78.96
	4	58.09	57.61
	Average	62.91	62.23
C.A.C. 126	1	49.06	46.26
	2	68.51	68.08
	3	78.57	77.31
	4	62.72	60.90
	Average	64.71	63.13
C.A.C. 128	1	66.34	65.85
	2	66.96	66.96
	3	69.95	69.09
	4	64.67	62.85
	Average	66.98	66.18
POJ 2878	1	70.94	70.08
	2	75.31	74.89
	3	73.79	73.36
	4	50.90	50.45
	Average	67.83	67.19
P.S.A. 7	1	57.14	56.29
	2	60.84	59.90
	Average	58.99	58.09

TABLE 2

Percentages of tasseling of different varieties of sugar cane

VARIETY	PLOT	TASSELING
	number	*per cent*
C.A.C. 117	1	71
	2	73
	3	67
	4	65
	Average	69.00
C.A.C. 126	1	64
	2	66
	3	59
	4	75
	Average	66.00
C.A.C. 128	1	95
	2	95
	3	99
	4	98
	Average	96.75
POJ 2878	1	90
	2	89
	3	83
	4	92
	Average	88.50
P.S.A. 7	1	51
	2	43
	Average	47.00

TABLE 3

Effects of detasseling upon the production and development of "lalas"

VARIETY NAME	TREATMENT	AVERAGE NUMBER AND LENGTH OF "LALAS" (25 STALKS COUNTED)	
		"Lalas"	Length of "lalas"
		No.	*cm.*
C.A.C. 117	Detasseled	3.72 ± 0.1453	148.6 ± 4.7633
	Control	2.96 ± 0.1769	125.0 ± 5.9113
	Difference	+.76 ± 0.2289	+23.6 ± 7.5916
		(Significant)	(Significant)
C.A.C. 126	Detasseled	3.80 ± 0.1619	105.0 ± 5.6847
	Control	2.72 ± 0.1403	143.4 ± 3.4898
	Difference	+1.08 ± 0.2118	−38.4 ± 6.6704
		(Significant)	(Significant)
C.A.C. 128	Detasseled	2.96 ± 0.1348	131.4 ± 3.8703
	Control	3.28 ± 0.1927	126.6 ± 4.8362
	Difference	−.32 ± 0.2352	+ 4.8 ± 6.1941
		(Insignificant)	(Insignificant)
POJ 2878	Detasseled	2.56 ± 0.07706	168.2 ± 2.6899
	Control	2.24 ± 0.1163	168.2 ± 2.6076
	Difference	+.32 ± 0.1392	
		(Insignificant)	
P.S.A. 7	Detasseled	3.20 ± 0.1428	107.8 ± 5.6010
	Control	2.56 ± 0.1481	85.0 ± 5.5552
	Difference	+.64 ± 0.2057	+22.8 ± 7.8886
		(Significant)	(Insignificant)

TABLE 4

Effects of detasseling upon the yield of cane of different varieties of sugar cane

VARIETY	TREATMENT	AVERAGE COMPUTED CANE PER HECTARE	
		Yield	Difference
		tons	*tons*
C.A.C. 117	Detasseled	65.9762 ± 5.6118	
	Control	61.8517 ± 7.3655	+ 4.1245 ± 9.2597 (Insignificant)
C.A.C. 126	Detasseled	62.3160 ± 4.6203	
	Control	53.5072 ± 3.3522	+ 8.8088 ± 5.7083 (Insignificant)
C.A.C. 128	Detasseled	63.2485 ± 6.5561	
	Control	66.6427 ± 2.8126	— 3.3942 ± 7.1339 (Insignificant)
POJ 2878	Detasseled	62.8007 ± 9.5104	
	Control	48.5137 ± 6.2323	+14.2880 ± 11.3705 (Insignificant)
P.S.A. 7	Detasseled	87.2435 ± 5.4904	
	Control	84.4970 ± 0.4991	+ 2.7465 ± 5.5130 (Insignificant)

TABLE 5

Effects of detasseling upon the purity of the juice of different varieties of sugar cane

VARIETY	TREATMENT	AVE. APP. PURITY	DIFFERENCE
		per cent	*per cent*
C.A.C. 117	Detasseled	83.590 ± 1.8046	
	Control	84.173 ± 1.2536	—0.583 ± 2.1973 (Insignificant)
C.A.C. 126	Detasseled	79.560 ± 0.9908	
	Control	84.733 ± 2.0112	—5.173 ± 2.2420 (Insignificant)
C.A.C. 128	Detasseled	81.890 ± 2.6529	
	Control	80.240 ± 1.9379	+1.650 ± 3.2853 (Insignificant)
POJ 2878	Detasseled	88.100 ± 0.6951	
	Control	87.083 ± 1.3901	+1.017 ± 1.5542 (Insignificant)
P.S.A. 7	Detasseled	89.400 ± 0.2698	
	Control	87.410 ± 1.8751	+1.99 ± 1.8944 (Insignificant)

TABLE 6

Effects of detasseling upon the yields of sugar per hectare and piculs sugar per ton cane of different varieties of sugar cane

VARIETY	TREATMENT	AVERAGE COMPUTED SUGAR PER HECTARE		AVERAGE COMPUTED SUGAR PER TON CANE	
		Yield	Difference	Sugar per ton cane	Difference
		piculs	*piculs*	*piculs*	*piculs*
C.A.C. 117	Detasseled	113.310 ± 11.6668		1.528 ± 0.0911	
	Control	111.193 ± 3.3756	+ 2.117 ± 12.1453 (Insignificant)	1.548 ± 0.0776	—0.020 ± .1197 (Insignificant)
C.A.C. 126	Detasseled	88.491 ± 6.4307		1.287 ± 0.0370	
	Control	83.112 ± 7.9841	+ 5.379 ± 10.2518 (Insignificant)	1.483 ± 0.0413	—0.196 ± .0555 (Slightly significant)
C.A.C. 128	Detasseled	88.002 ± 8.8274		1.367 ± 0.0867	
	Control	94.306 ± 8.6385	— 6.304 ± 12.3509 (Insignificant)	1.339 ± 0.0903	+0.029 ± .1252 (Insignificant)
POJ 2878	Detasseled	136.535 ± 13.7895		1.889 ± 0.0936	
	Control	97.815 ± 3.9403	+38.72 ± 14.3414 (Insignificant)	1.831 ± 0.1246	+0.058 ± .1558 (Insignificant)
P.S.A. 7	Detasseled	173.635 ± 16.7082		1.981 ± 0.0668	
	Control	163.419 ± 10.9556	+10.216 ± 19.9797 (Insignificant)	1.933 ± 0.1151	+0.048 ± .1331 (Insignificant)

ABSTRACT[1]

Cost of production of ginger, *Zingiber officinale,* in the College of Agricluture. PEDRO B. TIAMBENG. (*Thesis presented for graduation, 1935, from the College of Agriculture, with the degree of Bachelor of Agriculture No. 509; Experiment Station contribution No. 1149.*)—The objects of this work were: (*a*) to determine the cost of producing ginger; and (*b*) to determine the profit or loss per hectare on ginger produced in the College of Agriculture.

Two varieties of ginger, the Hawaiian and the Native, were used in this experiment. The Hawaiian variety was planted on slightly sloping, well-drained forest land which had never been planted to any crop. The Native variety was planted on a level, well-drained plowed field in which were some coconut trees. Between the trees, legumes had previously been planted as a catch crop. In this field, the Hawaiian variety was also planted. The soil in both lots is clay loam.

A native plow and a native harrow were used in preparing the field. In the unplowed culture a home-made mattock was used to dig the holes in the ground for planting the ginger. In harvesting, the same mattock was used in digging up the rhizomes.

The rhizomes were cut into pieces so that each seed cutting was at least 2.5 cm long. The seed cuttings were planted in hills about 25 centimeters apart in the row, one seedling to a hill.

The rhizomes harvested from the plowed culture were stored in a pit dug in the ground and covered with a sheet of galvanized iron. The harvest from the unplowed culture was put in long piles on the ground and covered with several layers of dried banana leaves.

The following results per hectare were obtained: The total labor cost for the plowed culture was ₱78.29 for the Hawaiian variety and ₱91.30 for the Native; for the unplowed culture, Hawaiian variety only, ₱53.40. The total annual land rent per hectare and the total cost of planting materials for the plowed culture was ₱49.17 for the Hawaiian variety and ₱35.18 for the Native; for the unplowed culture, ₱40.31. The total cost of production for the plowed culture was ₱128.09 for the Hawaiian variety and ₱127.23 for the Native; for the unplowed culture, ₱93.71. The yield in the plowed culture was 6,057 kgm. or 225.13 sacks for the Hawaiian variety and 4,112.30 kgm. or 166.49 sacks for the Native. In the unplowed culture the yield was 3,977 kgm. or 147.84 sacks. Under the plowed culture the total return from the rhizomes per hectare was ₱270.16 from the Hawaiina variety, and ₱149.84 from the Native variety. Under the unplowed culture the return was ₱177.41 (Hawaiian variety). The gain per hectare was, under the plowed culture, ₱142.07 for the Hawaiian variety and ₱22.61 for the Native variety. Under the unplowed culture, the gain for the Hawaiian variety was ₱83.70.

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[1] Abstract prepared as part of required theme work in English 3a, College of Agriculture.

—*Abstract by Martiniano E. Rosell*

A REVIEW: "COMMERCIAL POULTRY FARMING" [1, 2]

To the number of poultry books now in use, *Commercial Poultry Farming* is a valuable addition. The authors of the book are T. Burr Charles, Professor and Head of the Department of Poultry Husbandry, University of New Hampshire, and Homer O. Stuart, Professor and Head of the Department of Poultry Husbandry, Rhode Island State College. The experience of the authors as teachers of poultry husbandry in colleges and their contact with experiment stations, poultry farms, poultry organizations and commercial organizations interested in poultry products has given them opportunities for study of the different factors in poultry production.

The book contains interesting and reliable information relative to established and dependable practices in poultry farming. Information derived from years of scientific research, experiences and observations of practical poultry raisers has been transformed, developed or elaborated into suitable form for practical use by poultrymen. The book is "designed to aid the beginner as well as the established poultryman and may serve as a reference for the solution of management problems of both."

The book opens with a note by L. L. Scranton of Fargo, N. D. in which he briefly surveys the development in the science of poultry production and management since the middle of the last century. In the introduction, the authors give the qualifications of the persons who should engage in the business of poultry farming and tell us who should not venture in such business. The business, they say is exclusively, for persons "having initiative, experience and who are well informed." In the later part of the book is emphasized the importance of the "human factor". This factor, they claim, to a large extent determines success or failure in the business. "To succeed in the poultry business, one must possess an interest in it, combined with natural initiative, good judgment and ambition. The urge to succeed must be backed by careful attention to details. A successful poultryman has a sympathetic understanding of his birds, ability to observe, and the physical as well as the mental ability to put his observations into operation."

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[1] General contribution No. 535.

[2] CHARLES, T. BURR, AND HOMER O. STUART. 1934. Commercial Poultry Farming. xvi + 436 p., 193 fig., 90 tables. Danville, Illinois: Interstate Printing Company. Price $3.20, net.

The book has twenty chapters of varying lengths depending on the importance of the subject matter, and seventeen pages of valuable appendix. Chapter IV is devoted to battery brooding and laying batteries, a system of poultry production of recent introduction, still in the process of development and therefore there is much yet to learn about their management and utilization.

Poultry feeds and feedings are discussed in three long chapters, VII, VIII and IX. Causes, symptoms and means of control are each discussed briefly for each poultry disease known, in chapter XIX.

Of special interest is chapter XVIII, "Management Factors". Business collapse, according to the author, is often attributed to one's inability to fit himself and his operations to circumstances that may arise so as to maintain or improve what has been started. Poultry management "means a continual change in practices because of variable factors that must be effectively coped with to be successful. It is just as true of the poultry business as of any other that the operator must keep abreast of the times by altering his management practices in the light of new information if he is to meet competition and continue in the lead."

The illustrations, two of which are colored, are one of the valuable features of the book. Eighteen tables of tabulated matter, compiled from various sources, are included in the appendix.

ENGRACIO BASIO
Of the Department of Animal Husbandry

COLLEGE AND ALUMNI NOTES

In compliance with a telegraphic instruction from President Jorge Bocobo, of the University of the Philippines, the Philippine daylight saving time has been observed on the College campus beginning November 1, 1936. At midnight October 31-November 1, clocks were advanced one hour. All the activities of the campus have since been adjusted to the new time.

The faculty of the College of Agriculture has recently approved to recommend to the University authorities the institution of a special two-years course leading to the title of Associate in Agriculture. The first year will be identical with that of the degree course, but the second year will consist of certain elective courses, mainly in agronomy and animal husbandry. The new curriculum is designed primarily for those who may wish to acquire some training in technical agriculture for their immediate use in farming, but cannot go through the more rigid preparation in the degree course.

The following papers were read at the monthly meeting of the Los Baños Biological Club on October 29, 1936, at the College auditorium:

Prof. A. B. Catambay. Cost of production of cassava in the College of Agriculture.

Prof. Placido Dacanay. Some forestry problems in the Philippines.

Dr. Silverio M. Cendaña and Mr. Andres M. Mane. A preliminary study on the distribution of freshwater mollusks in Laguna de Bay.

The following faculty members of the College of Agriculture were convocation speakers at various institutions:

School of Forestry:

August 3. Prof. Josefa D. Diaz. Factors of success.

August 24. Dr. Rafael B. Espino. Adaptation forms in plants.

September 14. Dr. N. B. Mendiola. Possibility of *Gnetum gnemon* in the Philippines.

Pampanga Agricultural High School, September 26. Dr. F. M. Fronda. Poultry raising as a vocation.

Laguna High School, October 5 (World Day for Animals). Dr. L. B. Uichanco. Some interesting Philippine animals.

Miss Emma Sarepta Yule, professor of English emerita and until lately managing editor of *The Philippine Agriculturist*, was recently heard from by Dean B. M. Gonzalez from her new address at 1464 Chevy Chase N., Glendale, California, where she is making her permanent home. She said in part: "Will you please convey to my old colleagues my warmest greetings? My memories are so wholly delightful to recall almost each day of my life on the campus. The kindly pleasant comradeship—it was ideal. And the splendid students—to all greetings."

Mr. E. de Braganza Pereira, '21, has recently been transferred by his government to the Daman District, Portuguese India, as chief of the fourth agricultural division.

IN MEMORIAM

RICARDO LUGOD MERCADO. Born in Gingoog, province of Oriental Misamis, on March 6, 1913. Entered the College of Agriculture as a special student, enrolling in agronomy and animal husbandry, June 3, 1936. Died at Los Baños, Laguna Province, Novemebr 4, 1936.

"SO THE PEOPLE MAY KNOW" [1]

The benefits accruing from a widespread application of the principles of Jeffersonian democracy, which consist of independent investigation and free discussion, have been generally admitted. Political and diplomatic institutions have long recognized that adherence to these principles constitutes, not only a source of strength, but also an essential leaven for a vigorous growth of wholesome public opinion. Science, however, has until lately been rather reticent about taking the general public into its confidence. The scientists work all too often, as Dr. Melville J. Herskovits, of Northwestern University, so charmingly puts it, "in the seclusion of the laboratory and emerge only to administer a rebuke to those who would go too fast in drawing conclusions not as yet justified by the progress of the work." [2]

In a sense, this extreme caution is not without its justification. Popular press releases on scientific subjects are extremely valuable. They serve a worthy end in that they help sow among a great body of lay readers the seeds that would develop into a more universal appreciation of scientific work. Information on recent findings that may be applied to the betterment of conditions in the home and the community become available promptly. The cultural level is enhanced through a wider dissemination of science consciousness and the consequent orientation of thought among the masses along healthier channels. But such altruistic objectives apparently have not always been the motivating factor.

The name of the person and the institution originating a piece of work or an idea reported upon must be properly identified. Matters of this kind lose much of their authentic savor when begotten of anonymous parentage. Likewise, interested parties would otherwise find it difficult to secure supplementary information through further inquiry. Persons or institutions, however, are in this case but a means to an end, and not the end itself. The busy scientific worker cannot well afford to take the time from his productive pursuits and indulge in meaningless publicity stunts, such as musings about plans that may happen to strike his fancy at the moment, recommendations based on very little basic work or no work at all, coining of catch phrases, and allied methods of getting into print for the sake of some free personal advertisement. "We care for praise," admonishes Henri Bergson,[3] "in the exact measure in which we feel not sure of having succeeded; it is because we want to be reassured as to our own value of what we have done that we seek praise and prize glory. But he who is certain, absolutely certain, that he has brought a living work to the birth, cares no more for praise and feels himself beyond glory, because there is no greater joy than that of feeling oneself a creator."

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[1] General contribution from the College of Agriculture No. 534.

[2] Science 83 (1935): 215–222.

Not infrequently, when one feels "not sure of having succeeded," he becomes apprehensive and proceeds to look about, lest some more fortunate colleague get a better chance, and, by comparison, thereby draw attention to his own inadequacy. He becomes intolerant of the success of others and he would stop at nothing to obstruct or discourage the well-meant efforts of his co-workers. If it is ever within his power, he attempts to stifle worthwhile results, sometimes under the guise of "policy"; otherwise, he misses no occasion to disparage other peoples' findings or even their competence at every opportunity. Unfortunately for scientific work, this exasperating attitude, which is bound to creep up among any group of people, serves only to hurt, not the individuals against whom it is aimed, but the well-being of the country itself.

LEOPOLDO B. UICHANCO

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[3] Hibbert Journal 10 (1911): 24–44.

Bringing the College to its alumni at the Reserve Officers' Training School Philippine Army, Baguio. Center, first row: Dean B. M. Gonzalez

THE STONY LAYER IN PILI [1]

JOSÉ B. JULIANO [2]
Of the Department of Agricultural Botany

WITH FIVE PLATES AND ONE TEXT FIGURE

The origin and development of the stony layer in Angiosperms is an interesting study, especially in connection with the part that this structure may play on the development of the enclosed seed during germination. In *Canarium*, for example, attempts (Cabrera, 1932)[3] have been made to find ways and means that might facilitate the rapid germination of its seed. In such attempts an accurate knowledge of the structural make-up of this hard impenetrable covering of the seed of *Canarium* is of paramount importance. In fact a more extensive morphological and anatomical study of all stony layers from Philippine plants will have to be done in the future, not only to trace their origin and development, but also to enable us to throw some light on the possibilities of bringing about a more rapid and successful germination of their seeds.

Quisumbing (1925) undertook the study of the origin and development of the stony layers in Angiosperms. He worked on *Sassafras sassafras, Quercus velutina,* and *Prunus pennsylvanica* (var. Early Richmond), in connection with his more extensive treatise on the stony layers of most important groups of Gymnosperms. This was followed by Juliano (1926), who traced the origin and development of the stony layer or shell of *Cocos nucifera* Linn., the first work dealing with Philippine material. Later on, several minor papers have been published dealing with the origin of stony layers in some of our common fruit trees (Juliano, 1932, 1934; Juliano and Cuevas, 1932).

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[1] Experiment Station contribution No. 1150. Received for publication August 6, 1936.

[2] The writer is greatly indebted to Mr. Proceso E. Alcala, who helped in the preparation and gathering of some of the material for this study during the time that he was working as a Graduate Student Assistant in the Department of Plant Physiology.

[3] CABRERA, D. V. Some methods of propagation of pili (*Canarium ovatum* Engl., and *Canarium luzonicum* [Blume] A. Gray). (Thesis presented for graduation with the degree of Bachelor of Science in Agriculture, 1932. Unpublished.)

The present paper is a continuation of those cited above, and deals with the origin and development of the stony layer or shell in *Canarium ovatum* Engl. and *C. commune* Linn.

MATERIAL AND METHODS

The material used in this study was obtained from mature cultivated trees of *Canarium ovatum* and *Canarium commune* grown in the College orchard at the Experiment Station of the College of Agriculture, University of the Philippines Laguna. Numerous flowers and fruits at different stages of development were gathered from time to time from December, 1933 to January, 1935. Some material from *C. asperum* Benth. forma *villosum* H. J. L.[4] (Lam, 1932) was gathered from trees growing along the Molawin Creek on the same Campus. All the material was killed and fixed either in the field or in the laboratory with the use of formalin-acetic-alcohol (70 per cent), prepared according to the formula given by Chamberlain (1932), and treated as usual. This was embedded in paraffin, and sections 8 to 10 microns thick were cut. These sections were mostly stained in Heidenhain's iron-alum haematoxylin with aniline orange G dissolved in clove oil as a counterstain. Older stages were stained with safranin-light green or safranin-aniline blue combinations.

Free-hand sections of mature stony layer were made from material previously softened in concentrated hydroflouric acid for nearly a month. These sections were stained in Heidenhain's iron-alum haematoxylin or safranin. Rather thin sections of the whole stony layer were made as prescribed by Chamberlain (1932), and these were dehydrated in alcohol, cleared in clove oil, and mounted in balsam without staining.

OBSERVATIONS AND RESULTS

Macroscopical description. The shell of *Canarium ovatum* is trigonous and elongated (Pl. 5, fig. 33). The basal end forms an acute angle, while its apical or terminal end is more or less blunt or obtuse. The shell is tawny or ochraceous tawny to nearly dirty-brown on aging on the outside. Inside it is more or less brown, shiny and glabrous. When wet with water, the shell becomes slippery to the touch. It measures about 4.5 to nearly 5.5-6.0 centimeters in length, with a diameter of from 1.5 to 2.5 centimeters. When viewed from the basal end, the nut is distinctly trigonous (Pl. 5, fig. 42). In transverse section the nut is nearly triangular (Pl. 5, fig. 35) with its corners rounded and one of its sides wider than the others. On this broad side which is often concave or elevated, one can find the functional locule containing the mature seed. This broad side also possesses on the outside distinct grooves (Pl. 5, fig. 33) indicating the place where this shell breaks when the seed germinates (Pl. 5, fig. 36-37). The grooves have their counterparts on the inside portion of the shell (Pl. 5, fig. 43) as depressions circumscribing an arc near the central portion of the shell.

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[4] Synonym, *Canarium villosum* (Blume) F.-Vill. (Merrill, 1923).

Situated at the basal acute end are the three opennings (Pl. 5, fig. 42) or holes as remnants of the old vascular bundles (Pl. 5, fig. 33) which alternate with the loculi of the ovary (Pl. 5, fig. 41). At the center is another slit which proves to be the axillary vascular bundle to the ovary. The presence of these four holes or degenerated vascular bundles symmetrically arranged on this end of the shell gives it an appearance of a face of a man when viewed at this end, the two peripheral bundles simulating the eyes, the third bundle the mouth, and the central bundle the nose.

The shell of *Canarium commune* is also trigonous, and oblong (Pl. 5, fig 34*a*) but its corners are more prominently blunt (Pl. 5, fig. 34*b*) than thoes of *C. ovatum*. In some cases the shell may be obovate with the larger portion towards the apical end, and the smaller towards the basal end. One of its sides is also broader than the other two, and on this broad side is located the functional locule containing the seed. The basal end tapers gradually to an obtuse angle, while its terminal or apical end is more or less acuminate. The color is similar to that of *C. ovatum*. The shell measures 2.3 to 2.8 centimeters in diameter and 3.4 to 3.9 centimeters long; in other words, it is much smaller compared with that of *C. ovatum*.

The shell of *C. asperum* forma *villosum* is more or less ovoid (Pl. 5, fig. 38) to slightly trigonous (Pl. 5, fig. 39), small, with two ends tapering obtusely to sharp points, about 9 millimeters long and 8 millimeters in diameter. At one end are obscurely found the vascular bundles (Pl. 5, fig. 39). The outer surface is somewhat rugose (Pl. 5, fig. 38). In transverse section the shell, the sides of which are concave, is rounded or slightly triangular in outline (Pl. 5, fig. 40). On one of its sides is located the functional locule. Inside the shell in the functional locule are the depressed grooves which mark the thinnest portions of the shell, and where the embryo emerges during germination. On the outside the grooves are absent.

GERMINATION OF THE SEED AND STONY LAYER

Cabrera (1932) tried to germinate the seeds of *C. ovatum* and *C. commune*[5] some with their stony layers intact, others with shells cracked, and still others with their shells removed. He found that untreated seeds, that is, seeds with their shells unharmed or intact, gave the highest percentage of germination (71.8 per cent to 86.6 per cent as averages), while the shelled seeds germinated the earliest. It was further observed that seeds in the shells may remain viable for only 137 days from the time they are harvested under conditions existing in the College of Agriculture at Los Baños, Laguna. After that time they are no longer viable.

During the germination of the seed, water must enter the shell where the seed lies. Because of the slowness with which water penetrates the shell and the resistance that this shell usually offers to the germinating seed within, germination is very slow. Usually it takes from 27 to 41 days for the pili seeds to germinate. The question now before us, and the horticulturists in particular, is where and in what portion of the shell does water enter the functional locule first to reach the seed. In other words, where is the weakest spot in the shell surrounding the functional locule?

At a glance one is led to believe that water readily enters the fertile locule through the vascular bundles or holes at the basal end of the shell (Pl. 5, fig. 34*b*, 42). Unfortunately, however, these holes do not lead to any of the loculi, functional as well as nonfunctional (Pl. 5, fig. 41). The writer believes that water must enter the fertile locule first at a point or points where there is the least resistance, or where the shell surrounding that fertile locule is the thinnest. The possibility of the grooves found on the flattened side as avenues for water becomes obvious (Pl. 5, fig. 33). Examination of transverse sections of the shell (Pl. 5, fig. 35) will readily reveal that at these grooves, the stony layer is rather thick, and hence entrance of water through them will be rather slow also. Very often when a nut is cut transversely at its middle portion and its seed is removed, one can detect a thin portion near its basal end, when viewed between the eye and the light. The other half (apical portion) does not exhibit such a feature. At this basal portion of the shell just a few millimeters from the apex on the flattened side is perhaps the weakest spot and where water enters the fertile locule first. It can not be denied, however, that water can enter the fertile locule at all points on the shell, if given sufficient time. But what we are after now is the spot where the water first enters the functional locule. If the supposition of the writer can be proven correct, then a simple treatment could be devised to facilitate the entrance of water into the seed without exposing it to the attack of microorganisms. Furthermore, the danger of injuring the seed during the removal of the shell is prevented or minimized.

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[5] This species was called *Canarium luzonicum* (Blume) A. Gray by this author.

In an attempt, therefore, to determine the validity of the foregoing assumption, that is, that water enters the functional locule first at the basal end of the shell, fresh nuts of *Canarium ovatum* and *Canarium commune* were obtained from the Department of Agronomy through the courtesy of Dr. Leon G. Gonzalez of the Pomology Division. These nuts were immersed in dilute aqueous solution of eosin for a period of two weeks. A nut was removed daily for examination and series of sections of about 1 millimeter in thickness were made from the treated nuts with the use of a sharp hack saw. In order to prevent the eosin on the surface of the shell from spreading over the cut surfaces of the sections during cutting, the nuts were first soaked in very dilute solution of hydrochloric acid for ten minutes, and then washed thoroughly in running tap water.

Results of daily examinations of the serial sections of the soaked nuts reveal that eosin enters the vascular bundles first and fastest, but the color is confined to them and never penetrates any of the loculi, fertile or sterile. Four to six days after soaking, the color could be detected in the functional locule as well as in the seed coats near the basal end, which strongly indicates that the first entrance of the moisture must have been at this particular portion of the nut or shell. This finding points to a possibility of cutting off the shell a few millimeters at its basal end in order to facilitate the entrance of moisture into the seed during germination. However, care should be exercised in cutting off the shell at its basal end, because the radicle of the seed is located here, and if the cut is made too far, injury to the seed within will surely result.

Development. The development and origin of the stony layer in the two species of *Canarium* under discussion is essentially identical. Not very many specimens were obtained from *C. asperum* forma *villosum* so that this is not discussed fully in the text. In describing the development of the stony layer emphasis is laid on the shell of *C. ovatum,* and wherever any differences occur, mention is made in the text.

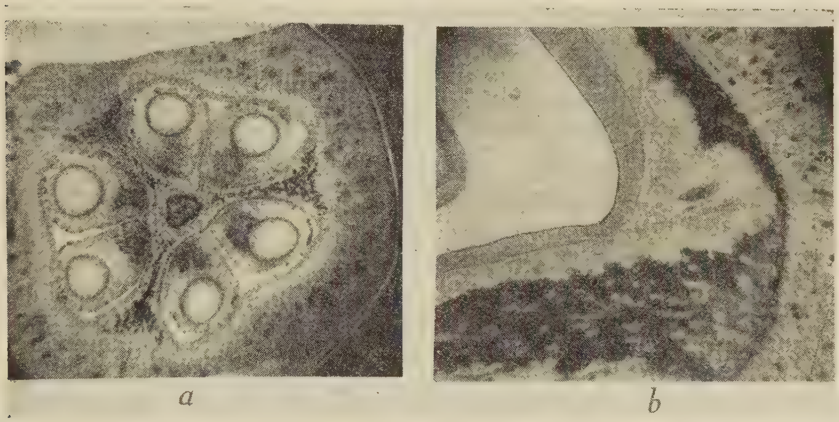
The tricarpelled ovary of *Canarium ovatum* Engl. is at first one-celled, but soon masses of meristematic cells arise at three points from the carpel wall, and meet at the center of the ovary, forming three partitions to the three loculi. Upon meeting each other at the center of the ovary, the edges of three masses of cells flatten themselves and each thrusts laterally on the two sides a row each of megasporange into each of the two adjacent loculi. In other words, in each locule we find two megasporanges which arise from the placentas derived from the adjacent carpels (Pl. 1, fig. 1). At this stage of development the ovary possesses distinct inner and outer epidermal layers in transverse section, between which is a homogenous mass of isodiametric parenchyma possessing large nuclei and dense cytoplasm (Pl. 1, fig. 2). The epidermal cells are more or less rectangular or squarish with their long diameters at right angle to the ovary wall. Traversing this mass of parenchyma are three vascular bundles corresponding to each of the three carpels composing the pistil. At the axis is a large vascular bundle (Pl. 1, fig. 1).

The homogeneity of the cells of the carpel wall becomes destroyed only when the flower bud is just emerging out of its bracts. The first tissue of the ovary wall to differentiate and enlarge is the innermost epidermal layer bordering each locule. These epidermal cells enlarge and become distinctly rectangular in transverse section with their long axes perpendicular to the circumference of the wall (Pl. 1, fig. 3). Simultaneous with the enlargement of the inner epidermal cells, three to four hypodermal layers of cells back of this inner epidermis also undergo enlargement to a slight degree, differentiating themselves pretty well from the rest of the homogeneous hypodermal cells of the ovary. The active enlargement and elongation of the epidermal cells are much more at the tangential portions of the loculi, than at the lateral sides or on the walls separating the loculi and at the axis of the ovary. A very distinct feature readily observable now is the complete absence of vascular bundles in this newly differentiated tissue of the ovary wall, the endocarp. This endocarp becomes the forerunner of the shell or stony layer to the fruit of *Canarium.*

In *Canarium commune* the inner epidermal cells bordering the loculi never elongate first, but exhibit right away active formation of periclinal walls (Pl. 4, fig. 26-27). Elongation only takes place after the series of periclinal walls are formed, and this activity is confined only to the outermost layer of sister cells (Pl. 4, fig. 28 and 29). In other words, cell division rather than enlargement is a feature of the innermost epidermal cells in this species, in contradistinction with those found in *C. ovatum.*

After the epidermal cells of *C. ovatum* have elongated and become rectangular, these divide successively by periclinal walls (Pl. 1, fig. 4), and these divisions are responsible for the addition of more tissue to the endocarp. This piling up of new tissues is much more active at the tangential portions of the loculi than on the lateral sides or walls of the loculi.

At the time the flowers have their petals emerging from their calyx lobes, we find that active divisions have slowed down and the innermost layer of cells become distinctly palisaded (Pl. 1, fig. 5), their inner tangential as well as lateral walls remaining thin, while their tangential walls directed towards the loculi are thickened. The hypodermal cells are rounded, rectangular or elongate, polygonal and thin-walled. Towards the periphery of the endocarp the cells contain an abundance of tannins, and the presence of this tanniferous tissue clearly marks out the endocarp from the exocarp. This tanniferous tissue (text-fig. 1*b*) formed at the periphery of the endocarp later becomes connected with those much more developed tanniferous cells found and formed very early in the walls separating the loculi of the ovary wall (text-fig. 1*a*).



Text fig. 1.—*Canarium ovatum* Engl. *a*. Photomicrograph of a young ovary showing the three loculi with two megasporanges each. Note formation of tanniferous tissue in walls separating the loculi and on the outer integuments of the megasporange. × 43. *b*. Photomicograph of a young stony layer (outer and inner stony layers) where breaking takes place during germination. × 43.

The endocarp at the two corners farthest the axis is the thickest. There are at these two regions the formations of elongated and polygonal cells in distinct rows (Pl. 2, fig. 13) and as these cells reach the periphery of the endocarp, they become tangentially compressed, narrow, and rectangular (Pl. 2, fig. 12). Another distinct feature about the palisaded cells at these regions is the fact that they do not elongate as much as those found at the middle portion of the tangential region of the epidermis (Pl. 1, fig. 6). Here the palisaded condition tends to be obliterated as rounded cells are almost always found mixed with the short palisaded cells, (Pl. 2, fig. 9-10).

The exocarp, on the other hand, is covered on the outside by a single layer of epidermal cells which are thin-walled and with their long axes tangent to the circumference of the ovary. These epidermal cells possess distinctly thicker outer walls which are cutinized, while their lateral and inner tangential walls are thin and made up of pure cellulose. Below the epidermis is layer of squarish thin-walled cells with their lengths nearly half that of the epidermis. Lying below this first hypodermal layer of cells is the extensive mass of isodiametric parenchyma of various sizes. These cells become large towards the middle and near to the edge of the exocarp, while those four to six layers of cells adjacent to the endocarp and abutting it are small, although also isodiametric. Scattered among these isodiametric parenchyma of the exocarp are tanniferous, widely-scattered masses of cells, numerous ramifying vascular bundles, and long, branched latex vessels.

The tanniferous tissue of the endocarp are mostly hexagonal or pentagonal in transverse section, flattened tangentially, and may range from 6 to 12 layers in thickness (Pl. 1, fig. 5). Later, these may increase in number. Even at this early stage of development the endocarp can be easily separated into two distinct regions; namely, (1) the inner palisaded cells or inner stony layer, and (2) the outer, extensive mass of variously shaped cells some of which contain tannin, the outer stony layer.

(*1*) *Inner stony layer.* The palisaded epidermal cells are longer and larger on the tangential portion of the functional locule than on the lateral sides and towards the axis of the ovary. These palisaded cells seem to exhibit a sliding growth (Pl. 1, fig. 6) and periclinal divisions, so that at the thickest portion of this stony layer there may be two to three layers of such palisaded cells, their end walls being either sharp or flat. At the lateral sides, even if periclinal divisions are evident, the cells remain short and narrow at first compared with those found at the tangential portion (Pl. 1, fig. 6). Later, however, they become similar in thickness and in development (Pl. 3, fig. 19-20). At the two corners, the stony layer consists of small, rectangular cells (Pl. 2, fig. 9-10) and often rounded to isodiametric cells are intermixed with them.

When the ovary has attained a diameter of about 1.5 centimeters, the palisaded cells show a marked waviness on their lateral walls (Pl. 1, fig. 7). This wavy character of the lateral walls of the palisaded cells are apparent in all the cells of the inner stony layer, with the exception of those found at the two corners. Here the cells remain practically straight-walled (Pl. 2, fig. 11), rectangular and long. The wavy character is perhaps a proviso for proper fitting of the cell together, and hence render the inner stony layer much more resistant to mechanical forces. This is perhaps another feature why the stony layer breaks at these two points during germination (Pl. 5, fig. 36-37) on account of the poor development of the palisaded cells here.

In *C. asperum* forma *villosum* the inner stony layer also exhibits the palisaded condition in its cells as well as the waviness of the lateral walls (Pl. 4, fig. 25).

At maturity the inner stony layer is distinctly lighter in color than the outer stony layer, thickest at the peripheral region and thinning gradually on the laterals and at the axis (Pl. 5, fig. 35). The thinnest is at the corners where breaking takes place (Pl. 5, fig. 36-37) and this is shown outside by the presence of grooves (Pl. 5, fig. 33). The cells composing the inner stony layers are rather uniform in shape. In transverse sections (Pl. 2, fig. 14) the palisaded cells nearing maturation are irregular in shape with distinct protuberances and thickened wall provided with distinct striations. In longitudinal sections the individual cells (Pl. 2, fig. 15) have rugged lateral walls which are thickened and lignified, exhibiting distinct lamellae. At full maturity the lumina are small and there seems to be a distinct formation of transverse canals across their walls. These lateral protuberances fit together very snugly, a condition which is perhaps responsible for the very homogeneous appearance of the inner stony layer.

(2) *Outer stony layer.* The outer stony layer possesses tanniferous cells at its periphery (Pl. 6, fig. 45). This tanniferous tissue may consist of from two to thirteen cell layers in thickness (Pl. 1, fig. 5) or more. The rest of the tissue consists of isodiametric, oblong, rounded to elongated cells, with thin walls. At the two corners far from the axis, the outer stony layer is the thickest. In here the cells are arranged in rows (Pl. 2, fig. 12-13) and their shape is mostly rectangular, becoming compressed towards the periphery. Except at the periphery (Pl. 6, fig. 45), the tanniferous tissue (Pl. 2, fig. 12-13) is absent in this place. At the lateral sides the outer stony layer

is also thin (Pl. 5, fig. 35) consisting of tanniferous cells and four to five layers of parenchyma. This thinness of the outer stony layer of the functional locule is compensated by the presence of the two degenerated loculi, which makes this portion of the shell somewhat thick.

As the ovary increases in size, the hyaline cells of the outer stony layer enlarge and assume various shapes. Their growth is perhaps sliding and they become tangentially compressed (Pl. 3, fig. 17). The cells seem to grow in groups so that while one group shows elongation longitudinally, the others elongate horizontally or in other directions. This peculiar habit of growth of the cells of the outer stony layer is easily seen through the longitudinal section (Pl. 5, fig. 32). Even in transverse section this peculiar growth is evident (Pl. 3, fig. 17).

Those cells at the corners remain rounded to isodiametric or else rectangular and their former arrangement is not altered at all (Pl. 4, fig. 30 and 31). This sliding growth of the parenchyma becomes more marked as the fruit matures, and in addition to this is the encroachment of tanniferous tissue towards the inner portion and to the utmost towards the inner stony layer. While this peculiar growth of the cells is taking place, the innermost layer abutting the innner stony layer becomes highly differentiated. The cells become enlarged, oblong (Pl. 1, fig. 7; Pl. 2, fig. 9 to 11; Pl. 3, fig. 20 and 21; Pl. 4, fig. 35) and rounded too, and forms the separation layer between the outer and the inner stony layer.

At maturity of the shell, the outer stony layer consists of oblong to elongated cells with thickened highly lignified wall. Running through the walls of the individual cells are large canals (Pl. 2, fig. 16; Pl. 3, fig. 23a). Those cells towards the periphery of the stony layer never become as thickened as those towards the interior. The innermost layer of cells of the outer stony layer are not so well lignified, and lignification is only evident towards their inner tangential walls but their lateral and outer tangential walls are comparatively thinner (Pl. 3, fig. 18).

At the regions near the degenerated loculi, the stony layer is covered by thin layers of lignified cells below which is the inner stony layer of the degenerated loculi. Consequently depressions are evident here (Pl. 5, fig. 43, 32*b*).

Examination of free hand sections of the whole mature shell shows that the outer stony layer is in general yellowish brown in color, and this coloration is due principally to the presence of tannins. The inner stony layer, on the other hand, is whitish. In the outer stony layer, there is the presence of colorless strips of cells arranged in rows at right angles to the periphery of the shell. In these strips are found small, rounded to oblong, longitudinally elongated cells in transverse section, the walls of which are lignified and thickened. In the colored regions of the shell the cells are comparatively large, thick-walled and mostly oblong to rounded in transverse section, with comparatively few longitudinally directed ones. At both corners of the shell bordering the functional locule is present an unbroken strip of colorless cells, most of which are longitudinally elongated and arranged in such a way that their long axes are at right angles to the circumference of the shell. This peculiar orientation of the cells at these two corners of the shell renders it not difficult for the young embryo to break through. Even if the presence of a few layers of colored, thick-walled cells at the outer region of the shell is evident, that would be insignificant compared with those found at other regions where the colored cells are present throughout the whole breadth of the shell.

Fate of the other loculi. In these species of *Canarium* there are present in the ovary three loculi, each with two megasporanges text-fig. 1*a*). As in the case of *Cocos nucifera* (Juliano, 1926) only one of the loculi becomes functional, the other two degenerate after fertilization. It is presumed that the megasporanges in all the loculi are potent enough to develop into a seed, if properly fertilized. There is, therefore, no possibility for anyone to tell off-hand which locule will function prior to fertilization.

The functional locule possesses two megasporanges and only one of them becomes actually fertilized, the other one simply degenerates (Pl. 3, fig. 21, 24). There is, therefore, a chance of finding two or even three seeds in a functional locule, one to each locule, in a nut of *Canarium,* if both megasporanges in a single locule, or one megasporange from each of the loculi, become fertilized at the same time. During the development of the fruit the two nonfunctional loculi are compressed by the functional locule (Pl. 5 fig. 35).

The development of the stony layer around the degenerating loculi is nearly the same as that found in the functional locule in *C. ovatum* and *C. commune.* There is marked elongation of the inner epidermal cells and enlargement of few hypodermal layers which early marked off the position of the stony layer (Pl. 1, fig. 8). Later development, however, differs very markedly. At the region towards the exocarp, we find the formation of few layers of tanniferous cells followed by few layers of hyaline cells inward, all constituting the outer stony layer (Pl. 3, fig. 19-20). The epidermis also exhibits the periclinal divisions similar to that taking place in the functional locule. At this region, therefore, a very narrow strip of stony layer results (Pl. 3, fig. 21; Pl. 5, fig. 35). Towards the axis as well as on the lateral regions of the walls separating the loculi, there is much more development of tissue.

As the ovary grows in diameter, these inner epidermal cells become palisaded also (Pl. 3, fig. 20), their walls becoming wavy (Pl. 3, fig. 19) later. Those few layers of hyaline cells in the outer stony layer become compressed and destroyed, with the exception of the innermost layer of cells which enlarge and become rounded, and serve as the separation layer between the inner stony layer and the outer. The tanniferous tissue, however, remains intact and is the only cover to the inner stony layer at maturity of the fruit (Pl. 5, fig. 35). At times even these few thick-walled cells of the outer stony layer slough off from the inner stony layer.

Lignification. The trend of lignification in the shell of *Canarium* is from the apical portion upward to the basal end. In the outer shell lignification starts with the outer tanniferous cells inward. Then these are followed by the colorless cells which occur in strips. The separation layer starts to lignify with the tanniferous tissue of the outer stony layer.

The inner stony layer becomes lignified at the same time as the hyaline cells of the outer stony layer, starting from the outer cells inward also.

The young cell contents are at first homogeneously scattered in the cell, and the development of the cell is accompanied by an increase in granular matter of the cytoplasm (Pl. 3, fig. 22-23), not only in size but also in number. Ordinarily the cytoplasm is observed near the wall where the material is piled up. Then vacuolation takes place, probably due to the diminution of water content and to the aggregation of the granules against the wall. After the vacuoles are fully formed, the granules disappear as the tissue again appears homogeneous. Pitting is very common among the lignified cells of the stony layer especially at mature stage.

SUMMARY AND CONCLUSION

Descriptions of the mature shell of *Canarium ovatum* and *Canarium commune* as well as that of *Canarium asperum* forma *villosum* are given. The origin and development of the shell or stony layer in *Canarium ovatum* and *C. commune* has been studied.

The shell as a whole is carpellary in origin; its inner portion (inner stony layer) arising from the innermost epidermal cells surrounding the loculi, while the thick outer portion (outer stony layer) develops from the numerous hypodermal cells of the endocarp.

Lignification of the stony layer starts from its apical end upward to its base and from the outside inward. Tanniferous cells of the stony layer are much more lignified than the hyaline ones.

The weakest and thinnest portion of the stony layer surrounding the functional locule is at its basal end where water first enters the seed. A simple device is suggested and described to effect a more rapid entrance of moisture into the seed.

Along the edges of the valve is present the thinnest inner stony layer as well as the outer stony layer with its nontanniferous, elongated, small to large thick-walled, lignified cells, the orientation of which favors easy separation or breaking, when the seed germinates.

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EXPLANATION OF PLATES

Figures 33, 34*a*, 34*b*, 36-40, and 42-43 were drawn by Mr. Marcos J. Aldama; the rest of the drawings as well as the photomicographs, were by the author.

PLATE 1

Canarium ovatum Engl.

Fig. 1. Diagram of a transverse section of a young ovary; *l*, loculi; *mg*, megasporanges; *vb*, vascular bundles. × 53.

2. Portion of a transverse section of the young ovary wall long before anthesis showing the homogeneous ground tissue and one of the juvenile vascular bundles (*vb*); *oep*, outer epidermis; *iep*, inner epidermis. × 235.
3. Portion of a transverse section of an ovary wall of a flower just emerging out of its bracts; *sl*, stony layer. Note enlargement of the inner epidermal cells to the locule as well as few layers of hypodermal cells. Some epidermal cells have already divided. × 235.
4. Showing three layers of cells resulting from periclinal divisions of the inner epidermis at the time the flowers have their petals emerging from the calyx lobes; *sl*, stony layer. × 235.
5. Portion of a transverse section of the pericarp showing part of exocarp (*ex*), outer stony layer (*osl*) with tanniferous cells near its periphery, and the beginning of the inner stony layer (*isl*). × 235.
6. Showing palisaded cells of the inner stony layer. Note arrangement and their end walls as well as differentiation of the innermost layer of the outer stony layer; *sep*, separation layer. × 235.
7. Portion of a transverse section of the pericarp showing exocarp (*ex*), outer stony layer (*osl*) with abundant tanniferous cells, and inner stony layer (*isl*) of palisaded cells separated from the former by a distinct separation layer (*sep*). × 99.
8. Portion of a transverse section of the ovary showing active formation of tissue in one of the sterile loculi towards the axis. × 235.

PLATE 2

Canarium ovatum Engl. and Canarium commune Linn.

Fig. 9. Portion of a transverse section of the inner stony layer of *Canarium ovatum* Engl. taken at the corner far from the axis of the ovary; *sep*, separation layer. Note the shape of the cells. × 410.

10. Portion of a transverse section of the inner stony layer taken at the other corner; *sep*, separation layer. × 410.
11. Portion of a transverse section of an older stony layer showing character of the lateral walls of its cells; *sep*, separation layer. Compare this with figure 7 of plate 1. × 235.
12. Portion of a transverse section of the stony layer taken at its thickest portion showing character of the cells towards the exocarp; *t*, tanniferous tissue. × 235.
13. Same stony layer taken about the middle towards the locule. × 235.
14. Transverse section of a nearly mature palisaded cell of the inner stony layer. × 540.
15. Portion of a longitudinal section of a palisaded cell from the inner stony layer. × 540.
16. Showing nearly mature stone cells from the outer stony layer of *Canarium commune* Linn. × 490.

PLATE 3

Canarium ovatum Engl. and Canarium asperum Benth, forma villosum H. J. L.

Fig. 17. Portion of a transverse section of the outer stony layer (*osl*) of *Canarium ovatum* Engl. showing sliding growth of its hyaline cells in its outer portion; *sep*, separation layer; isl, inner stony layer; *t*, tanniferous tissue. × 53.

18. Transverse section of the separation layer at the sterile locule showing lignification. × 235.

19. Portion of a transverse section of the shell at the sterile locule showing wavy character of the walls of the cells of the inner stony layer (*isl*), and the comparatively thin outer stony layer (*osl*); *sep*, separation layer; *lv*, latex vessels; *t*, tanniferous tissue. × 53.

20. Portion of a transverse section of the shell at the degenerated locule prior to the formation of the wavy walls by the cells of the inner stony layer; *isl*, inner stony layer; *osl*, outer stony layer; *sep*, separation layer. × 235.

21. Diagram of a transverse section of a young fruit showing the stony layer (*sl*), the loculi (*l*), and exocarp (*ex*). × 2.8.

22. Portion of a longitudinal section of the outer stony layer taken at its middle portion showing early stage in lignification. × 540.

23. Showing a more advanced stage in lignification of the cells of the outer stony layer. × 540.

23a. Showing a mature stone cell from the outer stony layer in transverse section. × 490.

24. Diagram of a transverse section of a young fruit of *Canarium asperum* forma *villosum* H. J. L. showing the stony layer (*sl*), exocarp (*ex*) and *loculi* (*l*). × 4.5.

PLATE 4

Canarium commune Linn., and Canarium asperum Benth. forma villosum H. J. L.

Fig. 25. Portion of a transverse section of the young stony layer of *Canarium asperum* forma *villosum* H. J. L.; *ex*, exocarp; *isl*, inner stony layer; *osl*, outer stony layer; *sep*, separation layer. × 235.

26. Portion of a transverse section of the ovary wall of *Canarium commune* Linn. at the tangential side of the functional locule showing early periclinal formation of walls by the epidermis. × 540.

27. Same epidermis taken near the axis of the ovary; *t*, tanniferous cells. × 540.

28. An older stage showing formation of several layers of cells derived from the epidermis and enlargement of the outermost layer; *isl*, inner tsony layer. × 540.

29. A much older stage of the stony layer showing palisaded condition of the outermost layer; *isl*, inner stony layer. × 490.

30. Portion of a tarnsverse section of the outer stony layer near the exocarp (taken where breaking takes place during germination). × 235.

31. Portion of a transverse section of the outer and inner stony layer (continuation of fig. 30); *isl*, inner stony layer; *sep*, separation layer. × 235.

PLATE 5

Canarium ovatum Engl., Canaruim commune Linn., and Canarium asperum Benth. forma villosum H. J. L.

Fig. 32. Showing longitudinal section of outer stony layer of *Canarium commune* Linn. prior to lignification. Note arrangement of cells. × 235.

33. Lateral view of the nut of *Canarium ovatum* Engl. showing the grooves (*gr*); *be*, basal end; *ae*, apical end. × 0.5.

34*a*. Lateral view of the nut of *Canarium Commune* Linn.; *ae*, apical end; *be*, basal end. × 0.5.

34*b*. End view of the same nut as its basal end. × 0.5.

35. Diagram of a transverse section of the mature shell of *Canarium ovatum* Engl.; *fl*, functional locule; *isl*, inner stony layer; *osl*, outer stony layer; *stl*, sterile locule; *vb*, vascular bundle. × 1.

36. Germinating seed emerging from the shell; *r*, radicle. Note region where breaking takes place. × 0.5.

37. A much older seedling; *cot*, cotyledon with seed coat; *r*, radicle. × 0.5.

38. Lateral view of a mature nut of *Canarium asperum* forma *villosum* H. J. L.; *ae*, apical end; *be*, basal end. × 2.5.

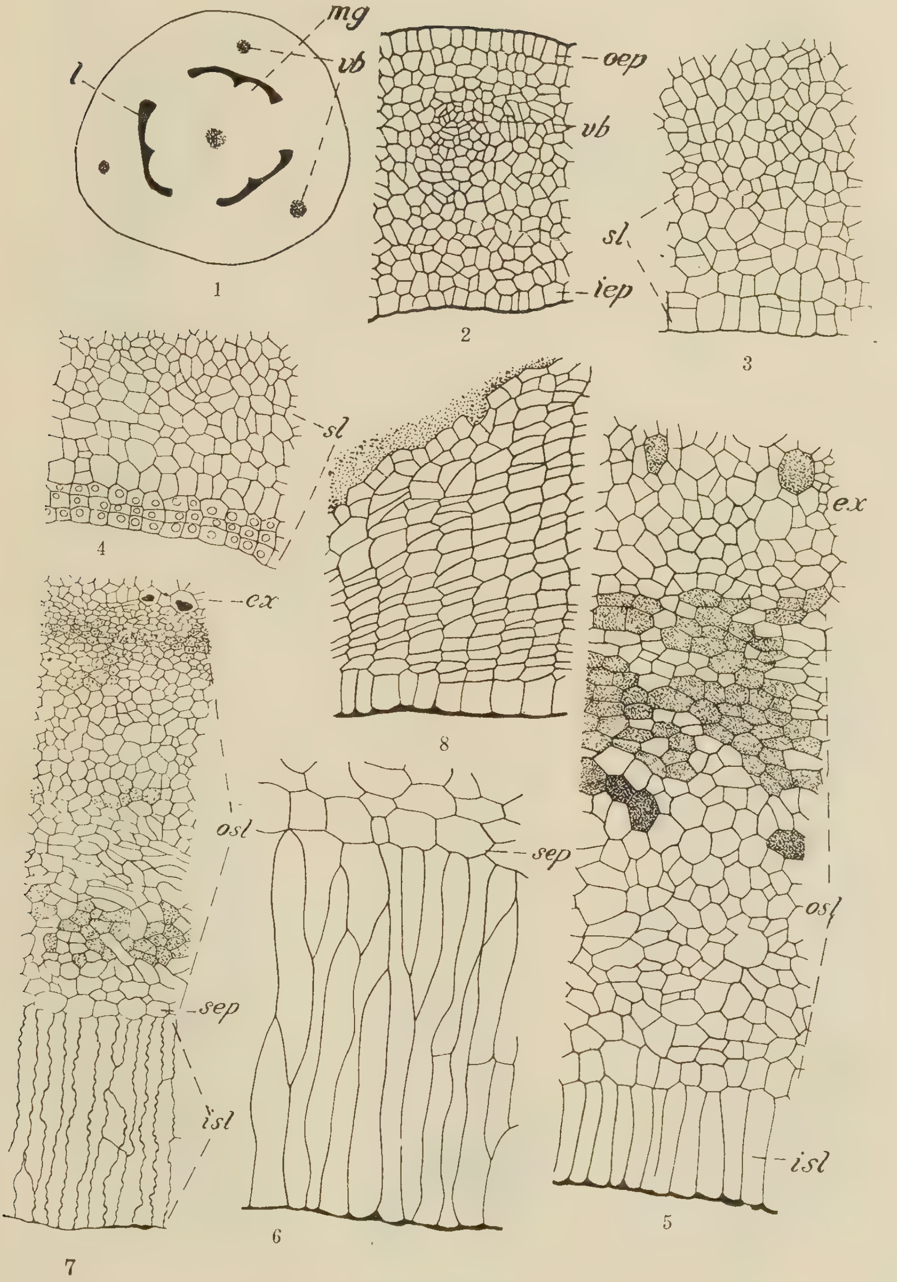
39. End view of the same nut at its basal end. × 2.5.

40. Diagram of a transverse section of the same nut showing the outer stony layer (*osl*), sterile locule (*stl*), functional locule (*fl*), and inner stony layer (*isl*). × 2.5.

41. Diagram of a transverse section of the nut of *Canarium ovatum* Engl. taken a few millimeters from its basal end showing position of vascular bundles in relation to the loculi; *fl*, functional locule; *cvb*, central vascular bundle; *stl*, sterile loculi; *vb*, vascular bundle. × 2.5.

42. End view of a mature nut of *Canarium ovatum* Engl. at its basal end showing the openings of the three vascular bundles. × 0.5.

43. Shell with half of it removed to show the groove (*gr*) inside where breaking of the nut takes place during germination; *isl*, inner stony layer; *osl*, outer stony loyer. × 0.5.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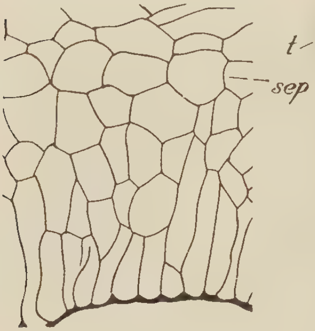

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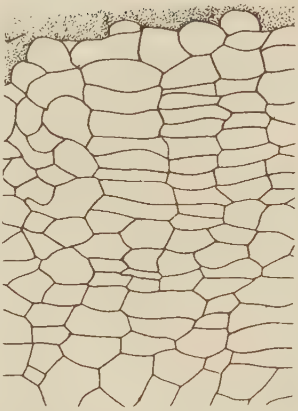

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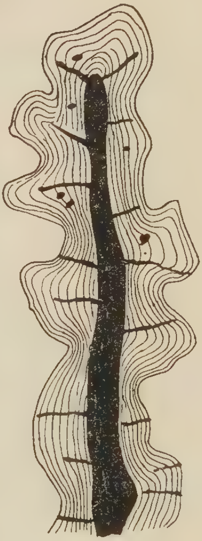

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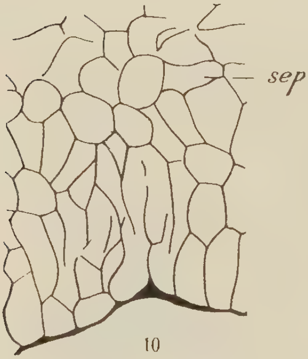

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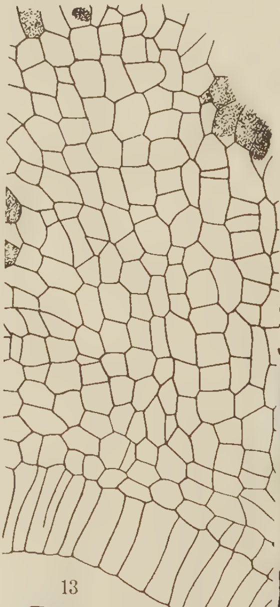

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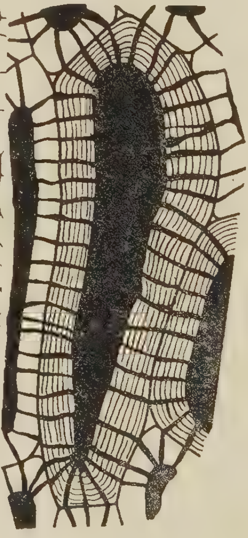

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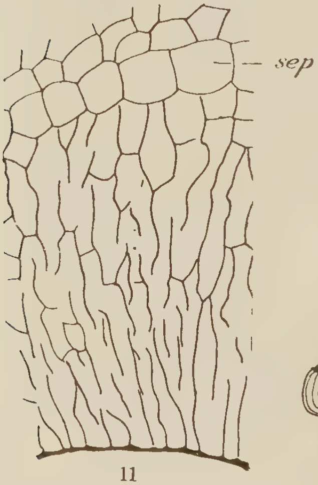

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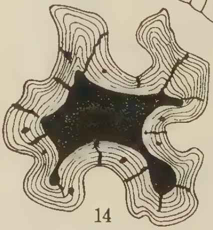

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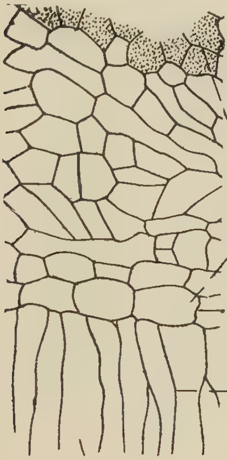

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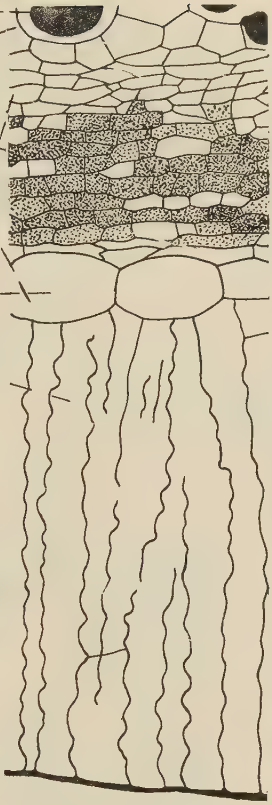
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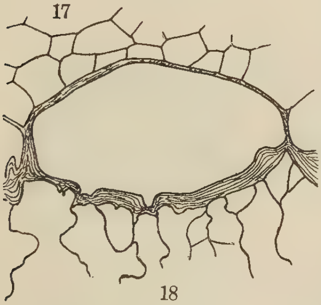

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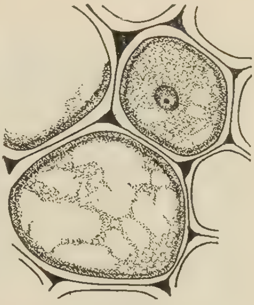

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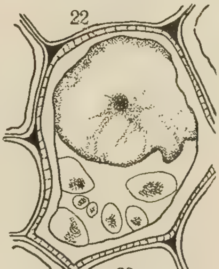

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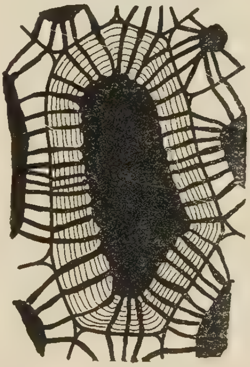

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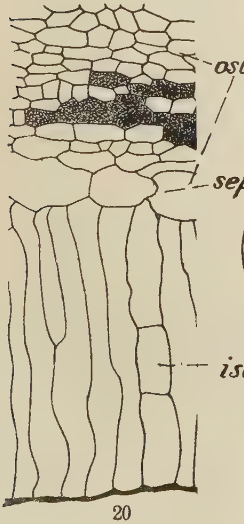

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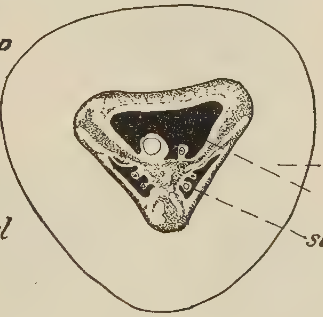

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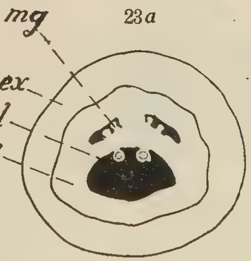

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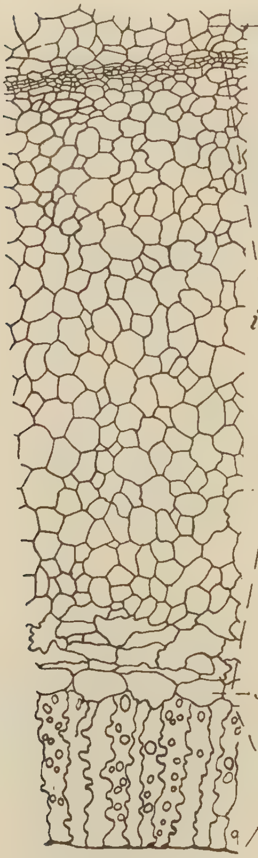
PLATE 3



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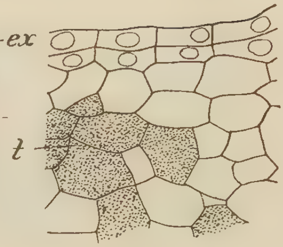

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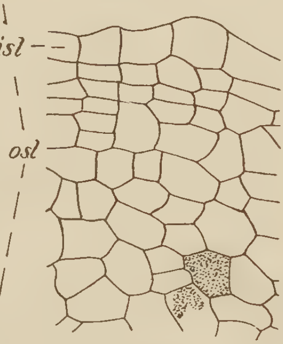

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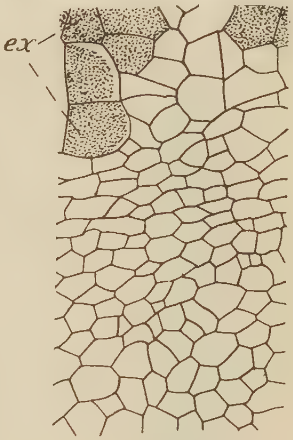

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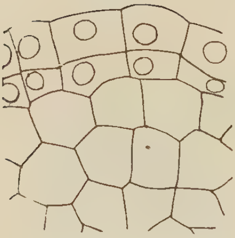

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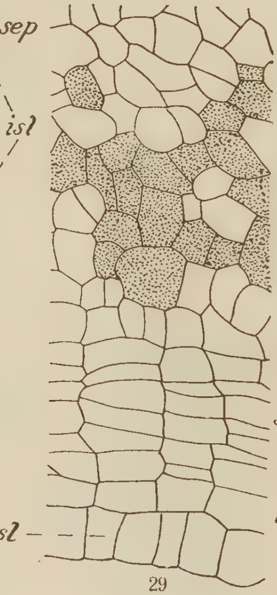

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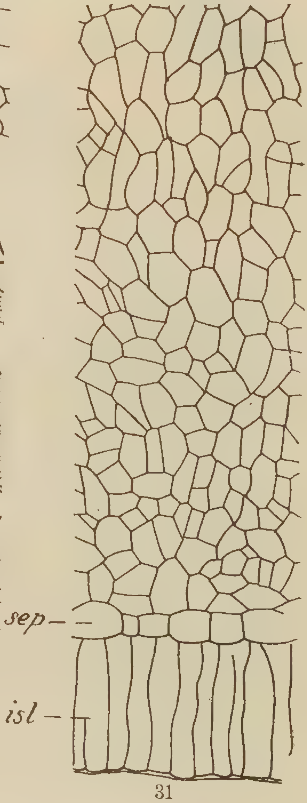

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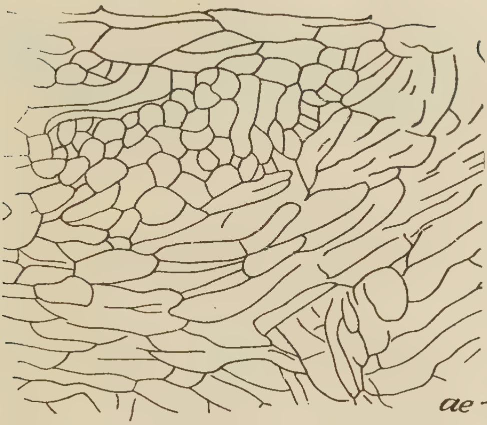
PLATE 4



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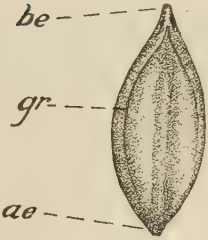

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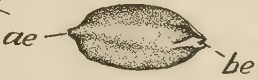

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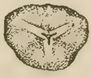

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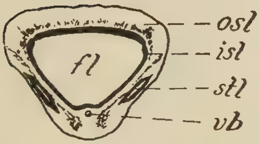
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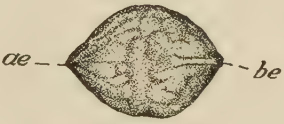

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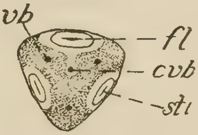
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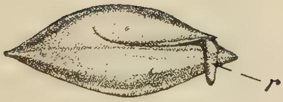

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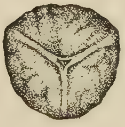

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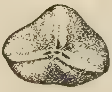

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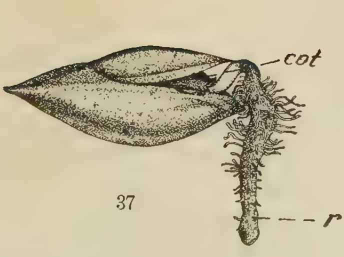

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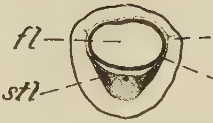

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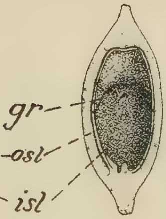

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PLATE 5

STUDIES ON THE PHYSICAL QUALITIES OF THE HEN'S EGG: V. AGE AND SEASONAL CHANGES AS FACTORS IN THE RATE OF DETERIORATION OF THE INTERIOR QUALITY OF LOS BAÑOS CANTONESE EGGS [1]

F. M. FRONDA AND D. D. CLEMENTE

WITH TWO TEXT FIGURES AND TWO CHARTS

It is common knowledge that as market eggs become older their value for table use decreases. This is due to the deterioration of the contents of those eggs. The more advanced poultryman tries to overcome this condition by selling the eggs as soon as they are collected from the nests, if possible, or by marketing the eggs at frequent intervals. During flush times, and if the poultryman wishes to wait for better times, he places his eggs in cold storage or subjects the eggs to some form of artificial preservation until the market price is better. It is to be regretted that the majority of the egg sellers in the Philippines follow neither of these practices. The eggs to be sold are generally placed in baskets, boxes, or on trays placed on sales tables where they are subjected to ordinary room conditions. Thus, it may be expected that the rate at which these eggs deteriorate in quality may be fairly rapid.

The experiments herein reported were conducted in the poultry laboratory, Department of Animal Husbandry, College of Agriculture, University of the Philippines, Los Baños, from November 1931 to January 13, 1933, covering a period of one year, two months and twenty-eight days, in order to determine the rate at which the contents of eggs kept at ordinary room conditions will deteriorate.

REVIEW OF LITERATURE

Benjamin (1923) described the contents of a new-laid egg as follows: "The fresh yolk should stand up round, being supported by the strong vitelline membrane; this membrane may show a few wrinkles but should show no weakening that would allow the yolk to flatten or to flow into the albumen. In the fresh egg, . . . the albumen is almost colorless, and stands jelly-like around the yolk, the dense portion emerging gradually into the watery outer layer. The chalazae are twisted hard and are relatively close to the yolk. No distinct cloudiness should appear in the albumen of a fresh egg."

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[1] Part of the expenses incurred in this study was paid from a research grant by the Philippine Poultry Association. The figures presented in this paper were taken from data contained in the thesis presented by the junior author for graduation, March 1933, with the degree of Bachelor of Science in Agriculture, No. 448; Experiment Station contribution No. 1152.

The liquefaction of the egg white is recommended by Holst and Almquist (1931) as a good method of determining the quality of the egg. From the results of their experiments they concluded as follows: "Shrinkage has little significance as an index to egg quality. Thick white percentage as an expression of egg quality possesses several points of superiority over the yolk index." They found that as the quality of egg becomes poorer the percentage of thick white becomes less.

Benjamin (1914) stated that the general condition of the layer, the ovarian and the oviduct conditions, are internal factors which may affect the quality of the eggs. Of the external conditions, temperature, which causes evaporation and incubation of the eggs, is an important factor that greatly affects the quality of the egg.

That bacterial contamination of eggs causes poor quality was shown by Jenkins and Hendrickson (1918), who found that there was a progressive rise in the percentage of bacterial contamination through the following series: Clean whole eggs, dirty whole eggs, clean cracked eggs, dirty cracked eggs, clean leaking eggs and dirty leaking eggs.

Sharp and Powell (1930) used what they call the "yolk index", found by dividing the height of the yolk by its width, as a means of determining the quality of an egg. It was shown by the results of their observations that the yolk index decreased faster at higher temperatures than at lower ones. According to their findings, the average yolk index of fresh eggs, possibly White Leghorn eggs, was 0.411.

The yolk index as suggested by Sharp and Powell (1930) was used by Stewart, Gans and Sharp (1932a) to determine the quality of eggs. They found the average yolk index of 578 newly laid eggs to be 0.409 as compared to 0.411, the average yolk index reported by Sharp and Powell (1930). Both groups of investigators reported that the vitelline membrane easily broke if the yolk index was 0.250.

Observations made on new-laid Los Baños Cantonese eggs showed that the yolk index varied from 0.389 to 0.569 with a mean of 0.472 ± 0.0027 (Fronda and Clemente, 1934). Fronda, Clemente, and Basio (1935) observed that no significant difference was observed between the yolk index of eggs laid during the hot, dry months and that of the eggs laid during the wet months.

The change in the color of the yolk as seen by candling has been used in determining the quality of the egg. In experiments by Stewart, Gans and Sharp (1932b), it was shown that as the yolk changed in color from light yellow to dark orange there was a corresponding lowering of the yolk index and a corresponding enlargement of the air cell. But the experiment showed that the relation between the candler's score of white and yolk color was not apparent.

Peters (1931), on the other hand, suggested the strength of the yolk as an index of egg quality. He said that if the yolk of an egg can be transferred from palm to palm of the hands for 40 to 50 times or more without breaking, the egg is of high quality.

PLAN OF THE STUDY

Twelve sets of observations, one for each month, were made. The period covered in each set was one hundred days. The first set was started on November 14, 1931 and the last on October 6, 1932. On the first day of every set, 185 Los Baños Cantonese eggs from the flocks of the College were collected. Ten of these eggs were set aside for the study on new-laid eggs and the rest were placed in a shallow box, 50 cm. long, 35 cm. wide, and 10 cm. deep, well padded with excelsior. These boxes were placed on a table in the laboratory, and the eggs were turned daily by transferring them from one box to another. Five eggs from this group were studied every three days.

The following qualities were observed: (*a*) Angle of inclination of the unbroken egg in tap water, (*b*) appearance and character of the albumen, (*c*) appearance and character of the yolk, and (*d*) development of the germ. These qualities were studied in ten new-laid eggs and in five eggs taken at random from the experimental lot at three-day intervals from the day of collection to the ninety-ninth day. The methods used in studying these characters were the same as those previously described by Fronda and Clemente (1934).

RESULTS AND DISCUSSIONS

Angle of inclination in tap water. New-laid eggs when placed in a beaker of tap water were found to sink to the bottom of the beaker with the two ends almost at a horizontal level. But when the angle of inclination of 10 new-laid eggs for each set was measured, the average for all the eggs was found to be 9.14 degrees; the butt (end containing the air cell) had a tendency to rise. As may be seen in table 1, the average angle of inclination of the eggs in the different sets varied from 6.7 degrees in the March set to 10.8 degrees in the November set.

These figures confirm the results obtained in a previous study by Fronda and Clemente (1934) who reported that, among other things, the angle of inclination of the new-laid eggs that they studied (in August) was 10.84 ± 0.181 degrees. Fronda, Clemente, and Basio (1935) reported also that "new-laid eggs produced during the dry season had significantly narrower angles of inclination when submerged in clear pipe water than those laid during the wet season."

By further reference to table 1, the following facts are revealed: (1) as the eggs became older, the angle of inclination increased; and (2) eggs of the same age varied in the angle of inclination. (See also chart 1.) The average increase in the angle of inclination as the egg became older was fairly uniform. A new-laid egg when immersed in water appears to be flat on its side. When the egg is about twelve to fifteen days old, the angle of inclination increases to a little over 50°, and this angle becomes about 90° when the egg is about one month old. The egg was observed to float invariably when it was more than one month old. (See also chart 2.)

Appearance and character of the albumen. In new-laid eggs, the albumen was opaque. This was observed to become less opaque as the eggs became older. As the eggs became older, the dense albumen became more and more watery, a condition that was also reported by Pennington, Jenkins and Betts (1918) and by Holst and Almquist (1931). It was further observed that the dense albumen of the eggs held during the hot months liquefied faster than that of eggs held during the cooler months. Some of the eggs observed possessed albumen that were of a greenish tinge. Although no careful observation was made of the variation in the color of the eggs held during the different months, it was noted that the greenish tinged albumen was associated with the eggs whose yolks were able to last long. A more careful observation of this particular character should be made.

The deterioration of the yolk. Tables 2 and 3 show the deterioration of the yolks of eggs at different ages. In breaking the eggs, the number of eggs with whole yolk in each period of observation was recorded. This, in terms of percentage, is shown in table 2. This table reveals that the yolks of the eggs laid in November, December, January, February and March lasted longer as whole yolks than those of the other months. In order to make a good comparison of the appearance of the yolks of the eggs held during the different months, it was necessary to have a standard, and for this purpose, if the eggs are broken into a dish and 80 per cent have whole yolk the eggs were considered still satisfactory for consumption. Under these conditions at room temperature the eggs of the November, December, January, February and March sets may be kept up to the age of 27 days and still be considered as fit for consumption; of the

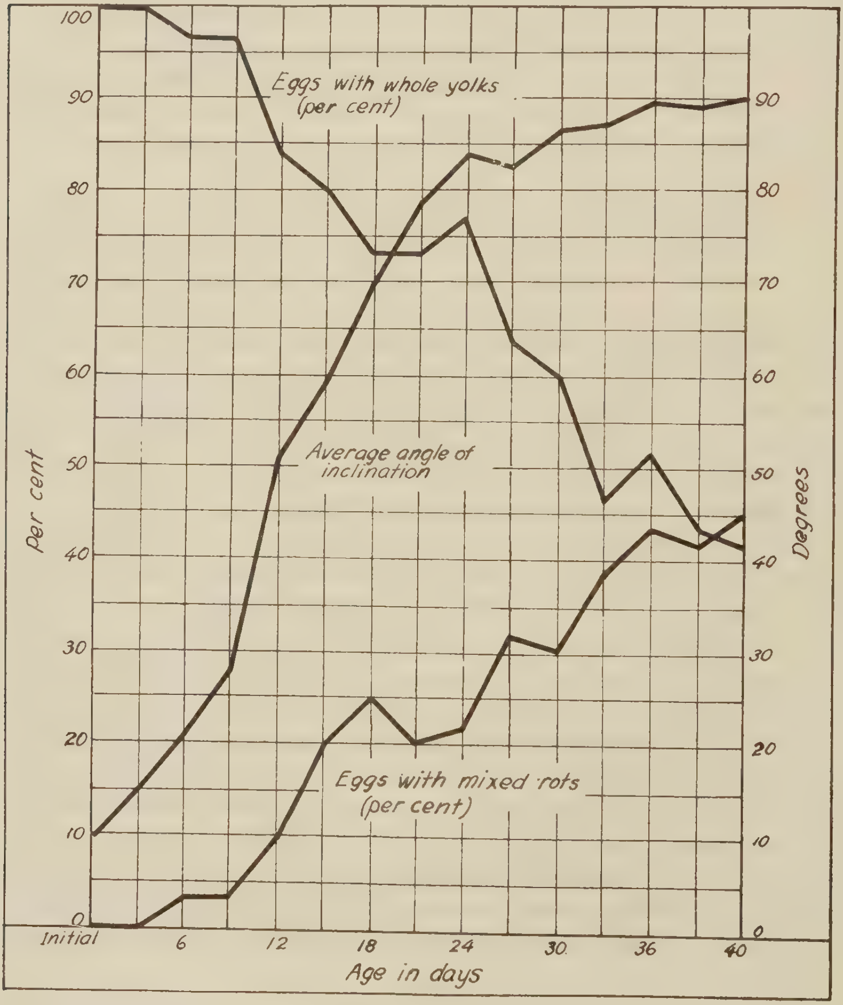

Chart 1.—Showing the average angle of inclination in tap water of eggs of different ages and held during different months. The condition of the yolks of the eggs are also shown.

April, May, and June sets up to the age of only nine days; and those of the July, August, September and October sets up to the age of 15 days. (See also charts 1 and 2.)

It may be noted in this connection that despite the fact that it was already rather hot during the months of February and March, the yolks of the eggs that were held during these months were able to hold out longer than was expected. It may not be out of place to suggest that these months being a part of the natural breeding season of chickens in this country (Fronda, 1928), Nature must have provided the eggs not only increased food materials as suggested by Funk and Kempster (1934) but also special protection against the rapid deterioration of these food materials.

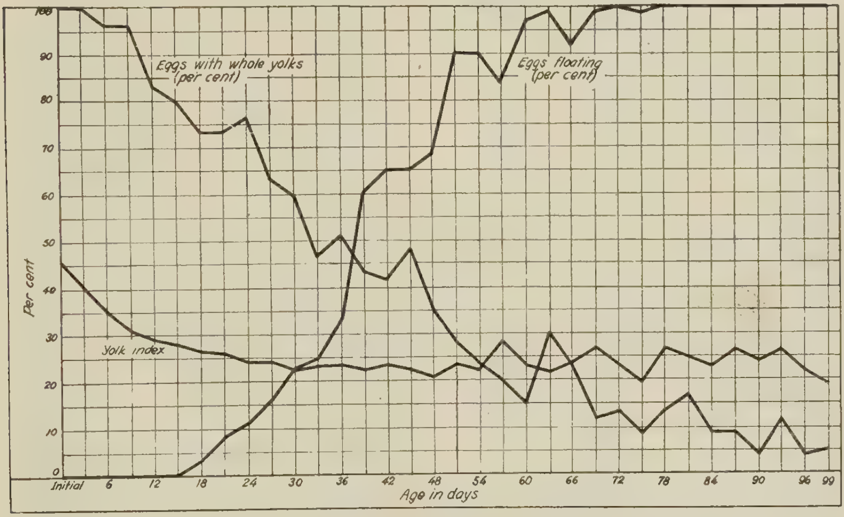

Chart 2.—Showing the percentage of eggs that had whole yolks at different ages. The average yolk index of the eggs as well as the percentage that were observed to be floating are also shown.

Most of those eggs that were found to keep long had thick shells and were not porous. The losses of weight in those eggs were observed to be much smaller than the losses of weight of the thinner-shelled eggs of the same age. The initial character of the yolk and white seems to have something to do with the keeping quality of an egg. Another factor that must be taken into consideration are the infertile eggs. Although the eggs used in this study were collected from "fertile" pens, there were some infertile eggs produced. It is known to practical poultry raisers that infertile eggs keep longer than the fertile ones. It may also be that most of the exceptional eggs have been laid by particular birds. A further study along this suggestion will be most timely. If the keeping quality of the egg is observed to be inherited, the problem of improving the keeping quality of market eggs may then be solved through proper methods of breeding.

The eggs in which the yolks were not entire were classified into mixed rot, white rot, black rot, dried yolk and stuck yolk, as shown in table 3. There were other characters as odor, meat spot, blood spot, blood ring, greenish white and hatch spots, but these characters were more or less associated with the above classifications. (See figures 1 and 2.)

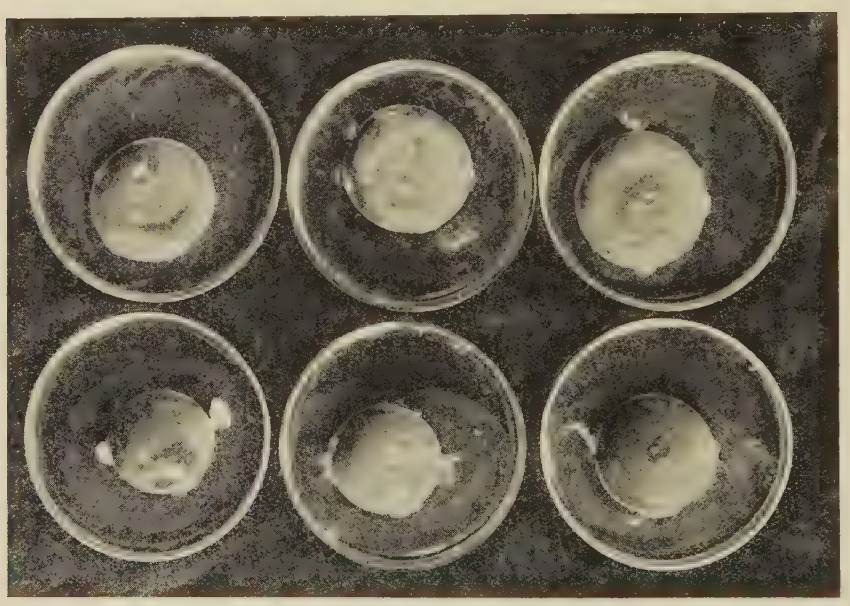

Fig. 1.—Showing the yolk and albumen of eggs of different ages. From left to right, lower row: newly laid egg, three-day-old egg, six-day-old egg; upper row: nine-day-old egg, twelve-day-old egg, and fifteen-day-old egg.

Table 3 shows the classification of the eggs of different ages based on all the eggs in the 12 sets. It will be noticed in this table that as the eggs became older the number of eggs with entire yolk decreased gradually. The number of mixed rots increased from 2 eggs or 3.33 per cent, of all the six-day-old eggs to 55.00 per cent of all the 48-day-old eggs studied, then decreased gradually up to only 10 per cent of the 99-day-old eggs. (See also chart 1.) The white rots began to appear on the 18th day and increased gradually up to the 99-day-old eggs. The last stage of the rot which is the black rot appeared first on the 27th day of the June set, and then appeared in one or two eggs at different ages, except in the 54, 75, 78, 81, 96 and 99-day-old eggs. Eggs with stuck yolks were found in the 12-day-old eggs, then appeared in some cases later. Dried yolk appeared for the first time on the 57th day of the April set.

The first two mixed rots came from the six-day-old eggs in the April set. This was the set subjected to the highest room temperature. This condition of some eggs appeared early in the hot months of March, April, May and August and late in the cold months of November, December, January and February. The other eggs in the other sets approached those of the hot months.

White rots appeared as early as the 18th day in the May set, which was only three days earlier than the appearance of this kind of eggs in the March set. There were more white rots in the hot month-sets than in any other month. This shows the effect of temperatures as one of the factors in causing the deterioration of the yolk. The occurrence of mixed rots was more frequent in the November set than in any other set. This was so because in the first month (November) there were many eggs with entire yolks while in the third month (January) the occurrence of white rots was more common. (See figure 2.)

The white rots began to occur more frequently when the mixed rots were decreasing in number. The yolks of the eggs were then undergoing changes from the mixed rot to the white rot stage of decomposition. It is supposed that the bacteria in the eggs increased in number hence the decomposition was advancing (Jenkins and Hendrickson, 1918).

Black rots and eggs with dried yolks appeared mostly in the old eggs. Black rots were most common during the rainy months of July, August, and September. It would appear that bacteria and fungi thrive best when there is much moisture, hence those that entered the eggs might have multiplied fast during these months. This may account for the more black rots during these months.

Dried yolks, on the other hand, were most common during the summer months. The rapid evaporation of the eggs in the March, April, and May sets eggs, (Fronda and Clemente, 1936) was undoubtedly the cause of the drying of the yolks of some of those eggs. Eggs with dried yolks upon examination were found to be eggs with thin and porous shells.

The yolk index. Fronda and Clemente (1934) reported that the yolk index of the one-hundred new-laid Los Baños Cantonese eggs that they observed varied from 0.389 to 0.569, with a mean of 0.472 ± 0.0027. In a later study on the influence of seasonal changes on the physical qualities of new-laid Los Baños Cantonese eggs, Fronda, Clemente and Basio (1935) concluded that there was no significant difference between the yolk index of eggs laid during the hot, dry months and that of the eggs laid during the wet months.

The yolk indices of the eggs held at different ages at different months of the year are given in table 4. By reference to this table, it may be seen clearly that the general trend is for the yolk index to become lower as the eggs become older, although variations in the yolk indices of the eggs of the same age occurred later as the eggs became older. The eggs included in the summer sets had lower yolk indices than eggs of the other sets. (See chart 2.)

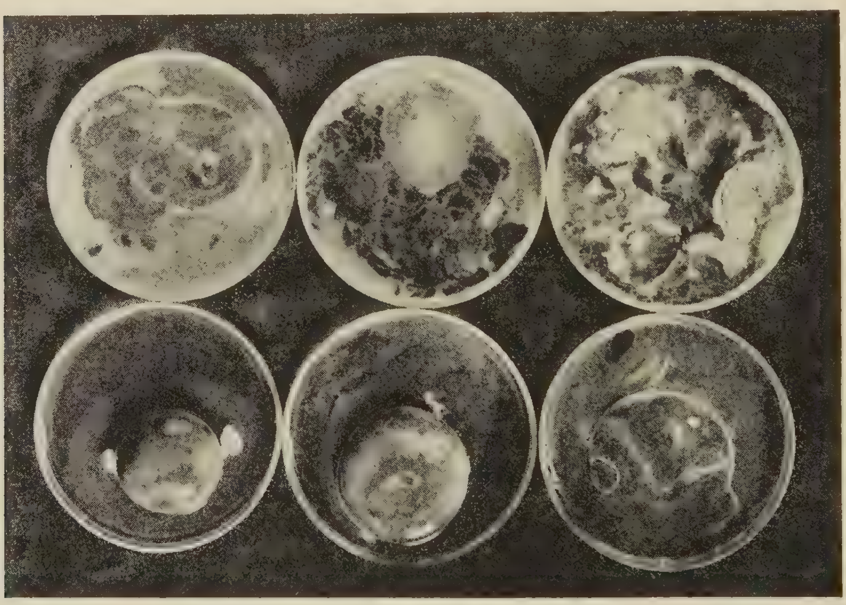

Fig. 2.—Showing the yolk and albumen of eggs of different ages. Lower row, left to right: newly laid egg, fifteen-day-old egg, thirty-day-old egg; upper row, forty-five-day-old egg, and ninety-day-old egg.

The standing quality of the yolk as measured by the yolk index (Stewart, Gans and Sharp, 1932a and Sharp and Powell, 1930), diminished with time. The older eggs had lower yolk indices than newly laid or fresher eggs. All workers on this problem are agreed that water passes from the white to the yolk, thus lessening the strength of the vitelline membrane, resulting in the flattening of the yolk. When the yolk flattens the height actually decreases and the width increases so that the yolk index is lowered. A further contributing cause of the flattening of the yolk on which workers on the subject are also agreed is that as the egg becomes older the white liquefies thus lessening its support to the egg yolk, especially at the sides. (Holst and Almquist, 1931 and Stewart, Gans, and Sharp, 1932b).

In this study it was found that some newly laid eggs, of the same weight and laid almost at the same time and observed at the same hour, showed differences in the degree of liquefaction of the white and in the dimensions of the yolk. These and other factors such as initial porosity of the shell, thickness of the shell, temperature and relative humidity undoubtedly affect the general applicability of the rule just found; namely, that the older the eggs, the lower the yolk indices.

The germ. Fronda and Clemente (1934) measured the size of the germ of 65 new-laid Los Baños Cantonese eggs and observed that these varied from 0.50 to 0.76 centimeter, with an average of 0.67 centimeter. That the size of the germ of new-laid Los Baños Cantonese eggs is influenced by seasonal changes was observed by Fronda, Clemente and Basio (1935), who reported that "there is a tendency for new-laid eggs produced during the dry season to have larger germs than those laid during the wet season." In the present study, increase in the diameter of the germinal disk in eggs that were held under laboratory conditions during different months was observed. These measurements are given in table 5. (See also figure 1.)

By reference to table 5, it may be seen that the increase in the diameter of the germ was very variable in different months. It was, however, most rapid during April, the hottest month of the year. As the eggs became older and the diameter of the germinal disk ceased increasing noticeably, the embryo was considered "dead" and the measurement stopped.

The development of the embryos of the eggs was fast during March, April, May and August. The 0.69 cm. average diameter for the three-day-old eggs of the February set was much smaller than the 2.36 cm. average diameter for the three-day-old eggs in the April set. This difference was no doubt due to the difference in the temperature during which the sets were held. The difference in the vitality of the germs of the eggs used might have also helped in causing the variations.

Strength of the yolk. Following the suggestion of Peters (1931), Fronda and Clemente (1934) determined the strength of the yolks of 100 new-laid Los Baños Cantonese eggs and observed that only twenty-six had yolks that could not be transferred from palm to palm more than forty times and the rest from 41 to 220 times. In the present study, it was found that as the eggs became older the strength of the yolk, as determined by Peter's process, became weaker. The average strength of the yolks of the 15-day-old eggs of the March set was found to be 20.8 times, of the April set only 2.0, of the May set 23.0, and of the August set 2.8. Those sets were subjected to very high temperatures. The 15-day-old eggs of the December, January, and February sets, were found to be 49.0, 48.6 and 52.4 times, respectively. The 15-day-old eggs of the other sets were intermediate between these two groups.

During the hot months, especially during April, the temperature was more favorable for the development of the embryo than at any temperature to which the other sets were subjected. It was noticed that the eggs with more developed embryos had weaker membranes than those whose embryos were less developed. The development of the embryo seems, therefore, to be another cause of the weakening of the yolk membrane. It was also observed that yolks with more developed embryos were more watery than yolks with less embryonic development. The passage of water from the white to the yolk weakens the yolk (Greenlee, 1911).

Besides temperature as a cause of variation in the weakening of the yolk membrane, the fertility and viability of eggs are also factors to be considered. Those two factors seem to hasten the passage of water from the white to the yolk. It was observed that a yolk with well developed embryo was more watery than a yolk with younger embryo. After a certain time the infertile eggs were observed to be of better quality than the fertile ones.

As a general rule, eggs kept beyond three days at an average temperature of above 26°C. are no longer of high quality and eggs kept around 25°C. are still of high quality up to the sixth day, if judgment is based on the 50-times standard for eggs of high quality (Peters, 1931).

Length of time eggs can be kept fit for consumption. In order to determine how long market eggs may be kept fit for table use it was found necessary to sample eggs of different ages by cooking. These eggs were of the following varying ages: Three hours old, 15 days old, 30 days old, 63 days old and 78 days old. These eggs were prepared as scrambled eggs. Ten persons were asked to sample the eggs and then requested to name them in the order that best suited their taste. It was surprising to note that two placed the fresh egg as having the best taste, one placed the 15-day-old egg as the best, four persons put the 30-day-old egg, three put the 63-day-old egg and one the 78-day-old egg.

From this simple test, it may be seen that eggs with mixed rots which characterized the 30-day-old egg and early white rot which characterized the 63-and-78-day-old eggs, respectively, can be eaten if scrambled. But Jenkins and Hendrickson (1918), and Jenkins (1918) are agreed in classifying such eggs as not edible owing to bacterial contamination. Owing to lack of study in the Philippines on the deterioration of eggs owing to bacterial contamination, the consumers and the producers should meet half-way by understanding that eggs may be still good for scrambling at the time when the yolk is about to break when opened. This condition falls usually at the age of 27 days for November, December, January and February, 15 days for March, April, May and June and 20 days for July, August, September and October.

When the eggs are intended to be eaten fried, they should be held a much shorter time. Ten students were asked to judge eight fried eggs of ages ranging from a newly laid egg to a 90-day-old egg. All of them were able to distinguish the newly laid from the 90-day-old egg. The hardest to place were the three-and six-day-old eggs. The 15-day-old eggs were intact when opened, but when fried the vitteline membrane broke loose easily.

For fried eggs, it is suggested that under Los Baños conditions during November, December, January and February, eggs for frying may be kept up to the age of about 10 days, about 6 days for March, April, May and June and about 8 days for August, September and October.

Determining the stage of deterioration of the contents of an egg by candling. Producers, dealers and consumers of eggs should be interested in the answer to the following question: Can the stage of deterioration of the contents of eggs held for various lengths of time be determined by candling? To be able to answer this question, the number of eggs correctly candled as checked by opening the egg was divided by the total number of eggs candled and multiplying the quotient by 100. This gives what was termed the "candling efficiency."

Based on the 2,021 eggs of various ages and representing different stages of deterioration, it was found that 90.20 per cent of the eggs with whole yolks were correctly candled, 52.90 per cent of those with mixed rots, 78.58 per cent of those with white rots, 90.57 per cent of those with black rots, 44.45 per cent of those with dried yolks and only 41.18 per cent of those with stuck yolks. It is apparent, therefore, that only the eggs with whole yolks and those that had black rots could be determined with a good degree of accuracy before a candler while those with the other stages of deterioration could not be very well judged through a candler. It is probable that with greater experience, these stages of yolk deterioration may also be determined with a fair degree of accuracy by candling.

SUMMARY AND CONCLUSIONS

A study on the relation to age of the deterioration of the physical qualities of market eggs held under ordinary room conditions is reported in this paper. Twelve sets of observations, each covering a period of 100 days, were made from November 15, 1931 to January 13, 1933. The eggs were studied in lots of tens for the control lots and in lots of fives in the experimental lots. The eggs in the control lots were less than twelve hours old when studied and those of the experimental lots varied in age from three to ninety-nine days old and were studied at intervals of three days.

The results obtained from this study may be summarized as follows:

1. The average angle of inclination of fresh eggs in tap water varied from 6.7 degrees in the March set to 10.8 degrees in the November set. As the eggs became older, the angle inclination increased.

2. When the egg was about ten to fifteen days old, the angle of inclination increased to a little over 50°. Eggs began to float at the age of 18 days and from this age, the number of eggs that floated increased to 75 days old.

3. Eggs at any age were found to either sink or float. No egg was found to stay midway in the water.

4. It was observed that the dense albumen of the eggs held during the hot months liquefied faster than that of eggs held during the cooler months.

5. The yolks of eggs held in November, December, January, February, and March were observed to last longer as whole yolks than those of the other months.

6. It was observed that as the eggs became older the number of eggs with entire yolks decreased gradually.

7. Mixed rots appeared early among the eggs held during the hot months of March, April, May and August and late in the cool months of November, December, January and February.

8. White rots were observed as early as the eighteenth day among the eggs held in May. More white rots were observed in the hot-month sets than during any other month.

9. There were more black rots formed during the rainy months of June, July, August, September and October than during the other months of the year.

10. Dried yolks were most common during the summer months.

11. The yolk index of fresh Los Baños Cantonese eggs was, on an average, 0.466 and for the one-month-old eggs, only 0.228. The general trend was for the yolk index to decrease as the eggs became older.

12. It was observed that some newly laid eggs of the same weight and laid almost at the same hour showed differences in the degree of liquefaction of the albumen and in the dimensions of the yolk.

13. The embryos of the eggs held during March, April, May and August developed faster than those held during the other months.

14. Eggs held during the cooler months had stronger yolks than those held during the hot months.

15. It was observed that for satisfactory results, during the hotter months and under ordinary room conditions, eggs may be kept up to six days if intended for frying and up to fifteen days, if to be scrambled. During the cool and rainy months eggs may kept about a week longer.

16. It was apparent that under the conditions in which these observations were made only eggs with whole yolks and those that had black rots could be determined with a good degree of accuracy before a candler, while those with the other stages of deterioration could not be very well judged through a candler.

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TABLE 1

Showing the average of the angle of inclination in clear pipe water of eggs[a] at different ages in 12 different sets

AGE OF EGGS	NOV. SET	DEC. SET	JAN. SET	FEB. SET	MARCH SET	APRIL SET	MAY SET	JUNE SET	JULY SET	AUG. SET	SEPT. SET	OCT. SET	AVERAGE	FLOATING[b]
days	*degrees*	*degrees*	*degrees*	*degrees*	*degrees*	*degrees*	*degrees*	*degrees*	*degrees*	*degrees*	*degrees*	*degrees*	*degrees*	*per cent*
Newly laid	10.8	9.1	8.6	9.8	6.7	8.2	9.3	8.0	8.7	10.6	10.2	9.7	9.14	0.00
3	14.0	19.8	11.2	11.4	12.2	14.7	15.0	12.0	14.0	15.6	17.7	16.2	14.48	0.00
6	22.6	22.4	13.0	19.6	16.6	38.0	20.6	20.0	16.0	17.7	15.4	20.4	20.19	0.00
9	32.8	23.8	31.2	30.2	25.0	66.0	20.4	28.2	19.0	20.0	15.8	20.6	27.75	0.00
12	58.6	64.4	29.0	71.6	62.0	86.0	27.0	40.4	36.4	59.6	25.8	42.0	50.23	0.00
15	71.6	42.6	40.2	72.0	72.0	90.0	60.2	76.0	56.0	39.8	44.4	43.4	59.00	0.00
18	53.2	54.4	42.8	83.5	79.2	88.7	66.4	75.0	82.6	77.8	75.0	54.8	69.45	3.33
21	74.8	76.6	68.8	70.0	87.0	90.0	79.0	76.3	75.6	81.6	88.0	76.0	78.64	8.33
24	83.0	76.2	66.0	88.0	82.0	90.0	90.0	89.5	82.8	87.0	89.0	80.0	83.63	11.67
27	80.8	73.0	65.6	90.0	89.0	—	83.2	85.0	81.0	89.0	85.4	83.8	82.34	16.67
30	80.8	86.0	80.0	90.0	90.0	90.0	90.0	83.5	90.0	90.0	75.5	87.0	86.07	23.33
33	81.0	85.7	85.0	—	90.0	—	89.3	86.5	90.0	90.0	88.3	82.2	86.80	25.00
36	88.7	86.2	90.0	90.0	90.0	—	90.0	90.0	90.0	90.0	90.0	90.0	89.54	33.30
39	90.0	84.5	90.0	90.0	—	—	90.0	89.3	90.0	—	88.8	90.0	89.18	60.00
42	90.0	90.0	90.0	—	—	—	90.0	89.0	90.0	—	90.0	90.0	90.00	65.00
45	90.0	89.8	89.0	—	—	52.0	90.0	90.0	—	—	90.0	90.0	85.10	65.00
48	90.0	90.0	90.0	—	—	90.0	—	90.0	—	—	45.0	—	82.50	68.30
51	90.0	90.0	—	—	—	—	—	—	—	—	90.0	—	90.00	90.00
54	—	90.0	—	—	—	—	—	—	—	—	90.0	90.0	90.00	90.00
57	90.0	90.0	90.0	—	—	—	—	90.0	—	90.0	90.0	90.0	90.00	83.33
60	—	—	—	—	—	—	—	—	—	—	—	90.0	90.00	96.67
63	90.0	—	—	—	—	—	—	—	—	—	—	—	90.00	98.33
66	—	90.0	—	—	—	—	—	—	—	—	—	90.0	90.00	91.67
69	—	—	—	—	—	—	—	—	—	90.0	—	—	90.00	98.33
72	—	—	—	—	—	—	—	—	—	—	—	—	—	100.00
75	—	—	—	78.0	—	—	—	—	—	—	—	—	78.00	98.33
78–99	All eggs floated to the surface													

[a] For each observation, five eggs from each of the 12 sets were taken every 3 days for study. Eggs which were floating were discarded. For the control 10 newly laid eggs were used in each observation.

[b] Percentage of the total number of eggs floating in all the 12 sets.

TABLE 2

Showing the average percentages of eggs with whole yolk at different ages in 12 different sets, computation based on opened eggs

AGE OF EGGS	NOV. SET	DEC. SET	JAN. SET	FEB. SET	MARCH SET	APRIL SET	MAY SET	JUNE SET	JULY SET	AUG. SET	SEPT. SET	OCT. SET	AVERAGE
days	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Newly laid	100	100	100	100	100	100	100	100	100	100	100	100	100
3	100	100	100	100	100	100	100	100	100	100	100	100	100
6	100	100	100	100	100	60	100	100	100	100	100	100	96.67
9	100	100	100	100	80	100	100	100	100	80	100	100	96.67
12	80	100	100	80	100	80	60	100	100	100	80	80	83.33
15	100	100	100	100	100	20	60	60	80	80	80	80	80.00
18	100	100	100	100	100	20	40	60	80	40	60	80	73.33
21	100	80	100	60	100	20	20	60	100	80	80	80	73.33
24	100	100	80	100	100	60	60	20	80	80	80	60	76.67
27	100	80	100	80	80	40	60	20	20	60	80	40	63.33
30	80	60	60	100	40	40	60	20	100	60	60	40	60.00
33	40	60	80	60	60	20	0	40	40	80	20	60	46.67
36	80	80	100	80	60	40	20	80	20	0	40	20	51.67
39	20	60	100	100	80	0	0	60	20	0	40	40	43.43
42	20	60	60	60	60	0	40	60	40	40	60	0	41.67
45	60	100	80	60	20	20	60	20	60	60	40	0	48.33
48	60	20	80	60	0	40	0	0	40	20	40	60	35.00
51	40	40	80	20	0	0	60	60	0	0	40	0	28.33
54	20	80	40	20	40	0	0	40	40	0	0	20	23.33
57	60	60	40	0	0	0	0	40	0	20	20	0	20.00
60	20	40	40	0	0	0	0	0	40	20	0	20	15.00
63	40	60	20	0	20	20	40	60	0	40	0	60	30.00
66	60	40	60	0	0	20	0	40	0	0	40	20	23.33
69	40	20	0	0	0	0	20	20	0	0	0	40	11.67
72	20	40	0	0	0	20	0	0	20	20	20	20	13.33
75	20	20	0	20	0	0	0	0	40	0	0	0	8.33
78	40	0	0	20	0	20	20	20	0	0	20	20	13.33
81	40	0	0	0	0	20	0	20	20	20	80	0	16.67
84	20	20	0	0	0	0	0	20	0	0	40	0	8.33
87	40	0	0	0	0	0	0	0	0	20	20	20	8.33
90	20	0	0	0	0	0	0	0	0	0	20	0	3.33
93	60	20	0	0	0	0	20	0	0	20	0	20	11.67
96	0	0	0	0	0	20	0	0	0	0	20	0	3.33
99	20	0	20	0	0	0	0	0	0	0	20	0	5.00

TABLE 3

Showing the condition of the yolks of eggs[a] *at different ages. Every egg in the 12 sets was considered*

AGE OF EGGS	CONDITION OF THE YOLK					
	Whole	Mixed rot	White rot	Black rot	Dried	Stuck
days	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*pet cent*
Newly laid	100.00	—	—	—	—	—
3	100.00	—	—	—	—	—
6	96.67	3.33	—	—	—	—
9	96.67	3.33	—	—	—	—
12	88.33	10.00	—	—	—	1.67
15	80.00	20.00	—	—	—	—
18	73.33	25.00	1.67	—	—	—
21	73.33	20.00	6.67	—	—	—
24	76.67	21.67	1.67	—	—	—
27	63.33	31.67	1.67	1.67	—	1.67
30	60.00	30.00	3.33	3.33	—	3.33
33	46.67	38.33	6.67	3.33	—	5.00
36	51.67	43.33	5.00	—	—	—
39	43.33	41.67	11.67	—	—	3.33
42	41.67	45.00	11.67	1.67	—	—
45	48.33	38.33	11.67	1.67	—	—
48	35.00	55.00	10.00	—	—	—
51	28.33	45.00	25.00	1.67	—	—
54	23.33	50.00	16.67	6.67	—	3.33
57	20.00	48.33	23.33	1.67	5.00	1.67
60	15.00	53.33	28.33	1.67	—	1.67
63	30.00	36.67	30.00	1.67	1.67	—
66	23.33	28.33	38.33	3.33	5.00	1.67
69	11.67	38.33	45.00	3.33	1.67	—
72	13.33	28.33	55.00	—	1.67	1.67
75	8.33	26.67	56.67	8.33	—	—
78	13.33	26.67	51.67	5.00	3.33	—
81	16.67	25.00	46.67	6.67	1.67	3.33
84	8.33	28.33	56.67	3.33	1.67	1.67
87	8.33	16.67	66.67	3.33	5.00	—
90	3.33	20.00	61.67	3.33	11.67	—
93	11.67	10.00	63.33	3.33	11.67	—
96	3.33	20.00	65.00	6.67	5.00	—
99	5.00	10.00	65.00	16.67	3.33	—

[a] There were 60 eggs studied in all the 12 sets at intervals of three days except in the control lot (newly laid) where 120 eggs were used.

TABLE 4

Showing the average of the yolk indices of eggs having whole yolk when broken at different ages in VB different sets

AGE OF EGGS	NOV. SET	DEC. SET	JAN. SET	FEB. SET	MARCH SET	APRIL SET	MAY SET	JUNE SET	JULY SET	AUG. SET	SEPT. SET	OCT. SET	AVERAGE
days													
Newly laid	0.468	0.460	0.452	0.477	0.464	0.452	0.454	0.468	0.459	0.488	0.479	0.476	0.466
3	0.389	0.443	0.424	0.423	0.410	0.369	0.398	0.427	0.365	0.386	0.417	0.422	0.406
6	0.353	0.402	0.370	0.360	0.358	0.298	0.349	0.346	0.378	0.311	0.378	0.366	0.356
9	0.313	0.351	0.344	0.321	0.340	0.269	0.281	0.308	0.328	0.327	0.299	0.295	0.315
12	0.306	0.301	0.352	0.308	0.290	0.256	0.271	0.287	0.283	0.327	0.286	0.275	0.295
15	0.307	0.291	0.305	0.292	0.243	0.192	0.303	0.261	0.271	0.372	0.271	0.286	0.283
18	0.299	0.301	0.280	0.263	0.247	0.289	0.235	0.246	0.244	0.244	0.271	0.267	0.265
21	0.253	0.282	0.280	0.260	0.239	0.250	0.289	0.219	0.262	0.286	0.286	0.235	0.262
24	0.243	0.299	0.261	0.229	0.207	0.234	0.260	0.280	0.211	0.189	0.239	0.263	0.243
27	0.221	0.244	0.287	0.201	0.197	0.198	0.260	0.304	0.217	0.276	0.285	0.257	0.246
30	0.246	0.274	0.210	0.201	0.183	0.242	0.235	0.203	0.238	0.212	0.232	0.228	0.225
33	0.217	0.225	0.233	0.194	0.173	0.260	—	0.268	0.256	0.268	0.277	0.242	0.237
36	0.266	0.242	0.197	0.228	0.175	0.259	0.312	0.283	0.144	—	0.240	0.271	0.238
39	0.234	0.252	0.232	0.190	0.155	0.324	—	0 234	0.177	—	0.230	0.241	0.227
42	0.232	0.280	0.210	0.155	0.163	—	0.279	0.328	0.211	0.251	0.231	—	0.234
45	0.199	0.218	0.203	0.174	0.222	0.290	0.224	0.242	0.219	0.245	0.235	—	0.225
48	0.213	0.204	0.199	0.210	—	—	—	—	0.188	0.220	0.244	0.190	0.208
51	0.242	0.230	0.212	0.199	—	—	0.211	0.297	—	—	0.252	—	0.235
54	0.238	0.208	0.232	0.195	0.189	—	—	0.278	0 218	—	—	0.198	0.219
57	0.227	0.224	0.213	—	—	—	—	0.290	—	0.443	0.282	—	0.280
60	0.240	0.185	0.176	—	—	—	—	—	0.160	0.304	—	0.313	0.230
63	0.203	0.221	0.171	—	0.117	0.286	0.239	0.253	—	0.267	—	0.211	0.219
66	0.225	0.231	0.177	—	—	0.206	—	0.268	—	—	0.239	0.258	0.229
69	0.269	0.238	—	—	—	—	0.249	0.352	—	—	—	0.215	0.265
72	0.300	0.202	—	—	—	0.282	—	—	0.187	0.218	0.236	0.194	0.231
75	0.169	0.200	—	0.180	—	—	—	—	0.216	—	—	—	0.191
78	0.184	—	—	0.322	—	0.219	0.282	0.336	—	—	0.235	0.272	0.264
81	0.228	—	—	—	—	0.227	—	0.271	0.257	0.272	0.221	—	0.246
84	0.158	0.213	—	—	—	—	—	0.289	—	—	0.242	—	0.225
87	0.203	—	—	—	—	—	—	—	—	0.294	0.293	0.267	0.264
90	0.224	—	—	—	—	—	—	—	—	—	0.254	—	0.239
93	0.261	0.189	—	—	—	—	0.267	—	—	0.312	—	0.295	0.266
96	—	—	—	—	—	0.226	—	—	—	—	0.204	—	0.215
99	0.159	—	0.127	—	—	—	—	—	—	—	0.266	—	0.184

TABLE 5

Showing the diameter of the germs of eggs at different ages held at different months

AGE OF EGGS	NOV. SET	DEC. SET	JAN. SET	FEB. SET	MARCH SET	APRIL SET	MAY SET	JUNE SET	JULY SET	AUG. SET	SEPT. SET	OCT. SET
days	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
Initial	0.63	0.69	0.64	0.65	0.64	0.60	0.70	0.64	0.60	0.63	0.61	0.62
3	0.88	0.82	0.72	0.73	0.74	2.36	0.89	1.09	1.23	1.05	1.11	0.93
6	1.62	0.94	0.80	1.05	1.22	—	1.59	2.46	1.58	2.36	1.49	2.11
9	2.14	1.37	0.97	1.98	2.11	—	3.32	—	2.09	—	2.38	2.52
12	2.98	1.17	1.09	1.36	2.44	—	—	—	2.78	—	2.24	—
15	2.87	1.37	2.16	1.75	1.98	—	—	—	—	—	—	—
18	4.00	1.82	1.11	1.96	—	—	—	—	—	—	—	—
21	2.70	1.76	1.08	1.77	—	—	—	—	—	—	—	—
24	—	1.48	0.90	1.83	—	—	—	—	—	—	—	—
27	—	2.30	—	1.82	—	—	—	—	—	—	—	—
30	—	—	—	1.20	—	—	—	—	—	—	—	—

PRESERVATIVES FOR WOODEN AND BAMBOO POSTS AGAINST GROUND-INHABITING TERMITES[1]

GUILLERMO A. PANGGA

In the Philippines, posts of houses of light materials and fences and other structures that come in direct contact with the soil are quickly destroyed by termites. The damage is mostly due to ground-inhabiting species of termites, which, because of their insidious habits, are very difficult to control. The use of concrete bases to isolate the upper wood from the ground, which has been recommended by a number of authors, because expensive, is certainly out of the question in such very temporary structures as the nipa shacks or fence posts of small yards. At best, therefore, the most that could be done is to save too frequent changing through reasonably cheap deterrent substances that would minimize termite attack and prolong the life of the post.

Nature of the problem

The object of the present paper was to find some cheap and effective ingredients that may be used in protecting for a reasonably long time fence or house posts that are set in the ground from termite attack.

Review of literature

Oshima (1919) states that camphor green oil itself when used in concentrated form is effective in preventing the attack of termites, but when it is too dilute, it is not very effective. The amount of oil required to prevent termite attack may vary with different kinds of wood.

Snyder (1924) in his experiments on methods of protecting wood against termites in the United States found that coal-tar creosote was the most effective reagent in rendering the timber resistant for from two to twenty years. The same author (1926) also suggests that a ten per cent solution of sodium arsenite is an effective poison for subterranean termites.

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[1] Special problem presented for graduation, March, 1936, with the degree of Bachelor of Agriculture from the College of Agriculture ; Experiment Station contribution No. 1153. Prepared in the Department of Entomology under the direction of Dr. Leopoldo B. Uichanco.

Kofoid (1934) points out that in California sapwood is more attractive to termite than heartwood, whether green or seasoned. This fact is, likewise, a matter of common observation in the Philippines.

Randall and Doddy (1934) state that commercial proprietary preservatives may be effective sometimes as a preventive against new infestations, where the surface of the wood is completely covered, but they seldom kill termite already present in the wood.

Uichanco (1931[a]) finds that water-oil treatment is an effective means of killing soil inhabiting termites and ants. The same author (1931[b]) found that immersion of plant cuttings for a short time in a one-to-ten dilution of coal tar-kerosene emulsion prevented damage from termites and apparently did not affect germination. Madrid (1934) obtained supplementary experimental data to show that immersion of plant cuttings in a 1:10 dilution of coal tar-kerosene emulsion from a few minutes to one hour did not materially affect viability and saved them from termite damage in the soil.

Time and place of the present work

The present work was conducted in the Department of Entomology, College of Agriculture, University of the Philippines, Laguna. The field tests were conducted in the pastures of the Department of Animal Husbandry. The work covered about three years, from July, 1932, to August, 1935.

MATERLIALS AND METHODS

Post materials

One hundred and twenty bamboo (*Bambusa spinosa*) and one hundred and twenty ipil-ipil (*Leucaena glauca*) posts were used in the present experiments. The posts were about fifty centimeters long. The bamboos were about one year old and they had a diameter of three to four and one-half inches. The ipil-ipil trees from which the posts were secured were about one and one-half years old; the posts measured from two to two and one-half inches in diameter.[2]

Preservatives

The preservatives used were coal-tar, crude table salt and Paris green.

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[2] The ages of both bamboo and wooden posts were estimated by a laborer who was hired to cut the materials.

Procedure

A place in one of the pastures of the Department of Animal Husbandry, known to be heavily infested by termites, was selected for setting the posts. Holes one meter apart were dug by means of a post-hole digger. The holes were arranged in twenty rows, twelve holes to a row.

The bamboo posts were divided into four lots, I, II, III, and IV. Each lot contained 30 posts. Lot I served as the control (no treatment). In lot II, the part of the post to be set in the ground (2/3 from the base) was dipped in coal-tar. In lot III, prior to setting the posts in the ground, three handfuls of salt weighing about 200 grams were thrown into the hole. In lot IV, three tablespoonfuls of Paris green, weighing about 65 grams, were scattered around the post in the hole.

The individual posts subjected to the different treatments were set alternately in replications. They were buried thirty centimeters deep at the base. In this arrangement no two posts receiving the same treatment were near each other.

Examination of the posts was made weekly. A small hole was dug in the ground near the sides of the wooden posts to facilitate observation of the part set in the ground. These holes were covered up after each inspection. In the case of bamboo posts, the part inside the ground was readily observed through the hollow opening of each post.

Collection of termites from infested blocks was made. Observation was carried on until all the posts were gone.

DISCUSSION OF RESULTS

Suitability of different treatments

Effectiveness. The results on the effectiveness of the different treatments are shown in table 1. It may be seen from this table that in wood, the percentage of attack in the control was 93.3 per cent; in coal-tar treatment, 90 per cent; in salt, 66.67 per cent; and in Paris green, 70 per cent.

In bamboo posts the control showed 80 per cent, coal-tar 70 per cent, salt 60 per cent, and Paris green 40 per cent.

Duration of protection (*table 1*). The number of days from setting of the posts to first sign of termite infestation in each was determined. Comparing the three ingredients used, it will be seen that in wooden posts, Paris green provided the longest protection against termite attack, 412.50 ± 8.55 days; salt second, 391.46 ± 9.88 days;

and coal-tar third, 354.22 ± 33.05 days. Coal-tar on ipil-ipil posts, however, showed an insignificant difference with control, 14.55 ± 33.85 days; the difference in favor of either Paris green and salt is significant. For bamboo posts, however, coal-tar and salt showed insignificant differences, with 13.73 ± 13.83 days and 31.32 ± 15.33 days, respectively, while Paris green showed a significant difference of 77-82 ± 16.17 days.

Cost. The total cost of each ingredient used in the different lots is shown in table 2. It will be seen in this table that in wooden posts ¼ gallon coal-tar, costing ₱0.57, was used for lot II, or at the rate of ₱0.0019 to each post; 5.5 kilograms of salt, costing ₱0.974, or ₱0.0032 to each post; 1.9 kilograms for Paris green, costing ₱4.18 or ₱0.1393 to each post. Comparing, therefore, the cost of treating each post in each lot, coal-tar is the cheapest, salt comes next, while Paris green is prohibitive. The same trend of results was found for bamboo posts.

Fungicidal effect

It will be seen (table 1) that the untreated posts whether attacked by termites or not, disintegrated much earlier than the treated posts. The untreated bamboo posts crumbled into powder from 440 to 804 days or an average of 559.26 ± 12.53 days after setting; coal-tar treated posts from 437 to 832 days with an average of 640.82 ± 10.67 days; salt-treated, 482 to 826 with an average of 655.07 ± 14.75 days; and Paris-green treated, 552 to 1008, with an average of 749.59 ± 16.39 days. The same general results were obtained for wooden posts. Except lots II and III in wooden posts, statistical study of the results shows that treatment gave very significant fungicidal effect, especially Paris green, on bamboo posts. It would appear, therefore, that in general, the ingredients in the quantities applied had some deterrent effect against decay-causing organisms. According to Brown and co-workers (1934), conditions which make for attack by termites are usually also favorable to the more familiar process of decay in wood products.

Species of termites that damaged the posts

Only two species of termites were observed to cause damage to posts in the present experiments; namely *Macrotermes gilvus* (Hagen) and *Microcerotermes los-bañosensis* Oshima. Infestation of bamboo posts usually began at the bottom. No tunnels were observed outside. Termites consumed the meat of the bamboo, leaving only the rind intact. In the case of wooden posts exploration tunnels were noted on the surface of the wood; usually many tunnels combined together and covered the entire surface of the block. Infestation began outside so that the bark of the wood was first damaged. It was likewise noted that termites began to attack the bottom end of the wood, going inward, so that most of the posts were found hollow. There were only six wooden posts infested by *Microcerotermes los-bañosensis* Oshima, and no bamboo posts. The greatest part of the trouble was due to *Macrotermes gilvus* (Hagen), which proved to be the most destructive. No species of *Coptotermes* was observed to attack the posts, owing doubtless to this form requiring a much drier condition. The place where the experimental plots were set was low and the soil was always moist because it was covered by grasses and shaded by big trees.

SUMMARY AND CONCLUSIONS

1. The relative effectiveness of coal-tar, salt, and Paris green against termite attack on bamboo and ipil-ipil posts set in the open was determined.

2. Coal-tar, salt, and Paris green are in general effective in preventing termite attack.

3. In the order of their efficacy on wooden posts, salt proved the best, with 66.67 per cent attack; Paris green next, with 70 per cent attack, and coal-tar last with 90 per cent. On bamboo Paris green showed 40 per cent attack, salt 60 per cent and coal-tar 70 per cent.

4. As to duration of protection, on wood, Paris green and salt showed significant differences with 72.83 ± 11.26 days and 51.79 ± 12.31 days, respectively. On bamboo, Paris green alone showed a significant dfiference of 77.82 ± 12.17 days.

5. As to cost of treating each post, either wood or bamboo, coal-tar was the cheapest with ₱0.0019; salt next, with ₱0.0032; Paris green dearest, with ₱0.1393. Paris green, therefore, is ruled out by the high cost.

6. As to fungicidal effect on bamboo posts, Paris green was the most effective, followed by salt and coal-tar.

7. Salt and coal-tar, although they showed some fungicidal effect on wooden posts, such effect was not statistically significant.

8. There were two species of termites found attacking the posts, *Macrotermes gilvus* (Hagen) and *Microcerotermes los-bañosensis* Oshima, the former being much more preponderant. *Coptotermes* was absent, evidently due to the condition of the experimental plots, which were too moist.

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TABLE 1

Showing the number of posts attacked in each lot, the number of days from setting of posts to the earliest observed attack to complete disintegration of posts

KIND OF POSTS	TREATMEMT	TOTAL AMOUNT OF INGREDIENT USED	POST			NUMBER OF DAYS FROM SETTING TO ATTACK			
			No. used	No. at-tacked	Per cent	Mini-mum	Maxi-mum	Average	Difference of two means (control minus treated)
					per cent	*days*	*days*	*days*	*days*
Wood (*Leucaena glauca*)	Lot I (control)		30	28	93.3	173	482	339.67 ± 7.34	
	Lot II (coal-tar)	1/4 gal.	30	27	90.0	154	468	354.22 ± 33.05	14.55 ± 33.85
	Lot III (salt)	5.5 kgm.	30	20	66.67	286	497	391.46 ± 9.88	51.79 ± 12.31
	Lot IV (Paris green)	1.9 kgm.	30	21	70.0	345	485	412.50 ± 8.55	72.83 ± 11.26
Bamboo (*Bambusa spinosa*)	Lot I (control)		30	24	80.0	168	485	349.65 ± 9.68	
	Lot II (coal-tar)	1/4 gal.	30	21	70.0	196	580	363.38 ± 9.88	13.73 ± 13.83
	Lot III (salt)	5.5 kgm.	30	18	60.0	286	643	380.97 ± 11.89	31.32 ± 15.33
	Lot IV (Paris green)	1.9 kgm.	30	12	40.0	335	749	427.47 ± 12.96	77.82 ± 16.17

TABLE 1 Continued

KIND OF POSTS	TREATMEMT	TOTAL AMOUNT OF INGREDIENT USED	POST			UNUMBER OF DAYS FROM SETTING TO DISINTEGRATION			
			No. used	No. attacked	Per cent	Minimum	Maximum	Average	Difference of two means (control minus treated)
					per cent	*days*	*days*	*days*	*days*
Wood (*Leucaena glauca*)	Lot I (control)		30	28	93.3	377	732	557.32 ± 31.82	
	Lot II (coal-tar)	1/4 gal.	30	27	90.0	437	748	635.58 ± 13.68	78.26 ± 34.63
	Lot III (salt)	5.5 kgm.	30	20	66.67	482	812	643.21 ± 50.67	85.89 ± 57.27
	Lot IV (Paris green)	1.9 kgm.	30	21	70.0	552	908	730.10 ± 20.39	172.78 ± 37.78
Bamboo (*Bambusa spinosa*)	Lot I (control)		30	24	80.0	440	804	559.26 ± 12.53	
	Lot II (coal-tar)	1/4 gal.	30	21	70.0	437	832	640.82 ± 10.67	82.53 ± 16.45
	Lot III (salt)	5.5 kgm.	30	18	60.0	482	826	655.07 ± 14.75	96.81 ± 19.27
	Lot IV (Paris green)	1.9 kgm.	30	12	40.0	552	1008	749.59 ± 16.39	191.33 ± 21.11

TABLE 2

Amount of ingredients used and cost of application

KIND OF POSTS	TREATMENT	INGREDIENT USED		NO. OF POSTS TREATED	COST OF APPLICATION PER POST
		Amount	Cost		
			pesos		*pesos*
Wood (*Leucaena glauca*)	Lot I (control)	—	—	30	—
	Lot II (coal-tar)	1/4 gal.	.057	30	.0019
	Lot III (salt)	5.5 kgm.	.0974	30	.0032
	Lot IV (Paris green)	1.9 kgm.	4.18	30	.1393
Bamboo (*Bambusa spinosa*)	Lot I (control)	—	—	30	—
	Lot II (coal-tar)	1/4 gal.	.057	30	.0019
	Lot III (salt)	5.5 kgm.	.0974	30	.0032
	Lot IV (Paris green)	1.9 kgm.	4.18	30	.1393

THE EFFECTS OF CERTAIN FERTILIZERS AND SOIL AMENDMENT TREATMENTS UPON TOTAL NITROGEN OF NANHAYA CLAY, A LOCAL RICE SOIL[1]

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WITH TWO CHARTS

Nitrogen relationships in rice soils have been the subject of much study by many investigators. It has been shown, that at least in certain rice soils, nitrogen is the only or the principal limiting element. However, unless other mineral elements are present in suitable amounts, nitrogen can not promote the growth of rice. The application of soil amendments, as lime ($CaCO_3$), sulfur (S), and sodium chloride (NaCl) has not yet shown any definite conclusion as to their merit.

REVIEW OF LITERATURE

Peralta (1927) found that when weeds as sedges, water hyacinth, cogon, and zacate were turned under the soil, the yield of both the straw and grains of rice was greater than that of the control. Used in this way, sedges proved to have the best effect; water hyacinth, cogon and zacate showed decreasing effects in the order named.

Joachim and Kandiah (1929) cited Nagaoka as reporting that more nitrogen can be utilized by the rice from late green manuring than from early.

Gericke (1927) working with solution cultures found that nitrogen, potassium and iron are essential for rice. He reported that calcium, magnesium, phosphorus and sulfur were not essential, and the ammonium salts are not needed in the solutions. He further reported that ammonium salts are useful only in making the solution acidic and thus rendering iron available for the plant.

Bartholomew (1929) found that nitrogen, whether in nitrate, organic, or ammonia form, seem to be available for rice if other growth factors, such as reaction, temperature, and light, are maintained uniform in all treatments. He concluded, however, that ammonium sulfate is the best fertilizer because rice seems to be little affected by the changes it produces and there is little probability that nitrogen may be lost by denitrification.

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[1] A portion of the thesis presented for graduation, 1935, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 1154. Experiment station contribution No. 511. Prepared in the Department of Soils under the direction of Dr. Robert L. Pendleton, formerly, head of the Department. Received for publication August 29, 1936.

Borja and Torres (1930), working at Alabang Experiment Station, found that 100 kgm. of ammonium sulfate per hectare were not enough, as out of five trials only two gave a real increase in yield. They also found that phosphoric acid and potash applications in the same kind of soil failed to give any decided advantage in production, that nitrogen is the limiting element in the Alabang soil, and that this element becomes more effective when it is combined with phosphoric acid and potash. Of the last two nutrients, potash is the more effective.

According to Mack and Haley (1929), soil treatments with ammonium sulfate and muriate of potash under anaërobic conditions, decreased the rate of nitrification in the soil. Lyon and Buckman (1930) cited Hart and Paterson who found that plants remove as much sulfur as phosphorus from the soil. The content of sulfur in soils was as low as that of phosphorus. Hart considered sulfur as a catalytic fertilizer which aids plant growth by accelerating natural soil processes. Bear (1931) claims that sodium chloride has no direct value as plant nutrient, but it influences the total concentration of the soil solution and has been found effective in increasing crop yields under certain circumstances. Regarding potassium chloride, Bear (1929) also stated that it can be substituted for sodium chloride provided that this salt is applied in greater amounts than the potassium chloride. Lyon and Buckman (1930) are of the opinion that sodium chloride may have a direct nutritive action, in influencing the chemical and biochemical transformation in the soils. However, the use of sodium chloride as a soil amendment is not recommended except in certain cases.

Objects of the present work

The objects of the present work are: (*a*) to measure the amount of nitrogen occurring in Nanhaya clay; (*b*) to determine periodically the effects of certain fertilizers and soil amendments upon the total nitrogen content of the rice soil: and (*c*) to determine the relations between the total nitrogen in the soil and the growth and yield of Ramai rice.

Time and place of the present work

This work was conducted in the laboratory of the Department of Soils, except the digestion of soil samples for the nitrogen determination which was done in the laboratory of the Department of Agricultural Chemistry. The rice cultures were grown in the yard adjacent to the Soils Laboratory.

The work covered the period from November, 1933, to December, 1934.

MATERIALS AND METHODS

Plan of study. The plan of these studies is as follows: (*a*) to determine the total nitrogen content of rice soils variously treated repeatedly with fertilizers and soil amendments. (*b*) to measure the yield of straw and grain of the rice from the soil so treated.

Preparation of the pot cultures. For the purpose of this experiment, one hundred water-tight petroleum cans (19-liter capacity) were used. The cans were arranged in four rows with 25 cans in a row, about 10 cm. apart in both directions. These cans were buried about 25 cm. deep in the ground; about ten centimeters were left exposed. Each of the four rows of cans were lettered A, B, C and D, respectively. The four cans of the same number from each row was called a set.

The soil. The soil used was Nanhaya clay. It was taken from various places in the field between about 70 and 100 meters east of the place where the Experiment Station road crosses the railway. The soil was well mixed, the large clods broken up, and the cans filled with it up to within 5 cm. of the top. The soils were treated as follows:

Row number	*Amount applied per can grams*	*Rates per ha. kgm.*	*Treatment*
1	—	—	Control
2	200.00	3412	Rice Straw
3	200.00	3412	Grass straw
4	200.00	3412	Legume
5	20.00	341	—$CaCO_3$
	200.00	3412	Grass straw
6	20.00	341	$CaCO_3$
	200.00	3412	Rice straw
7	3.00	51	$(NH_4)_2SO_4$
	200.00	3412	Rice straw
8	50.00	853	Rice straw ash
9	20.00	341	$CaCO_3$
10	40.00	682	$CaCO_3$
11	3.00	51	$(NH_4)_2SO_4$
12	6.00	101	$(NH_4)_2SO_4$
13	6.00	101	$(NH_4)_2SO_4$
	20.00	341	$CaSO_3$

14	2.50	42	$CaH_4(PO_4)_2$
15	5.00	85	$CaH_4(PO_4)_2$
16	4.00	68	KCl
17	8.00	136	KCl
18	4.00	68	KCl
	2.50	42	$CaH_4(PO_4)_2$
19	3.00	51	$(NH_4)_2SO_4$
	4.00	68	KCl
	2.50	42	$CaH_4(PO_4)_2$
20	3.00	51	$(NH_4)_2SO_4$
	2.50	42	$CaH_4(PO_4)_2$
21	0.75	21	Sulfur
22	1.50	25	Sulfur
23	1.50	25	Sulfur
	20.00	341	$CaCO_3$
24	5.00	85	NaCl
25	10.00	170	NaCl

The rice straw, grass straw and green legumes were cut into pieces about 2 cm. long before they were applied to the soil in the cans. Stock solutions of the other fertilizers were prepared and the proper amounts applied to the soil in the cans.

The indicator plants. Rice of the Ramai variety was used in this experiment. The seeds were first allowed to germinate in a can containing the same kind of soil as that in the experiment cans.

There were two plantings made in this experiment. The first, in the experimental cans, was made in June, 1933. In transplanting, four seedlings were planted in each can. The plants were irrigated from time to time. Two weeks after transplanting, the various fertilizers, straws, green manure and soil amendments were applied. This first crop was harvested on December 30, 1933. The weight of only the grains from each can was taken. The result is shown in table 3. No attempt was made by the author to analyze the soil.

The second planting was made on January 30, 1934. The same cans and soil were again used. Transplanting was done on February 18, 1934. The same number of seedlings as in the first crop was transplanted. The soil was kept in a saturated condition. Two weeks after transplating, the same kind and amount of fertilizers and soil amendments were applied in each particular can as has been applied the first time. The second crop was harvested on December 26, 1934. The height of the plant, from the base of the plant to the end of the longest leaf of the highest plant in each can, was measured twice during the growing periods of the rice. The results are shown in chart 2. The air dry weight of the straw and of the grain from each can was also taken and is shown in chart 2.

Collection and preparation of soil samples. No sampling of soils was made during the first crop. Collections of soil samples were made only during the growth of the second crop. There were four samplings made as follows:

a. Before flooding the soil—February 3, 1934.

b. After flooding, before fertilizing—March 1, 1934.

c. Soon after fertilizing—March 21, 1934.

d. At the maturity of the crop—December 26, 1934.

Samples for soil analysis were taken with a small diameter soil auger, as the use of the sampling tube did not give good results. Two borings were made to the bottom of each of the cans.

The soil samples were placed in separate bags and were allowed to dry at room temperature, after which they were pulverized and sieved through a 2-mm. sieve. Composite samples of cans A and B and of cans C and D were made for the nitrogen determination.

EXPERIMENTAL RESULTS

Chemical analysis of the soil for total nitrogen.

The method of analysis followed is that given in the *Official and Tentative Methods of Analysis* by the Association of Official Agricultural Chemists (1930).

The final average of the total nitrogen content of the soils on the four collection dates is shown in chart 1.

Observation on the cultures. The rice plants were observed and notes taken during their growth. In the notes emphasis was laid upon the general appearance, culm development and height. The description of each plot began four months after they were fertilized, for this was the time when the plants showed marked effects from the treatment given. A final observation was made during the booting stage.

Treatment 1. Control. The growth of the plants in the control was relatively poorer than that of any of the other plants. The culms had an average height of 88.8 cm.[2]

Treatment 2. This treatment gave a better growth than the control, which had a height of 100.0 cm. At the booting stage the growth of these plants was also rapid and they attained an average height of 155.5 cm.

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[2] All figures represent the average height of the plants of four cans, and the decimal was reduced to tenth unit considering 0.05 as 0.10. The first data on the height of the plant were taken four months after fertilizing. The description with the height was also taken during the booting stage.

Treatment 3. The plants were generally vigorous and in height much better than those under treatment 2. The height was 110.8 cm. At the booting stage, the growth of the plants was rapid and they attained a height of 163.5 cm.

Treatment 4. The plants in this treatment gave a very good growth, in fact the best of all the treatment. The plants in this treatment with an average of 132.5 cm. was one of the two highest in the experiment. However, shortly before the booting stage, many of the culms died. The stalks were very slender and weak. They attained a height of 163.8 cm. In vigor, plants of number 3 had a better growth than this treatment.

Treatment 5. The plants in this treatment had as good a growth as those of No. 4, with a height of 122.5 cm. at four months old. Toward the approach of the booting stage, the growth was better than in No. 4. At this time, the plants under this treatment were the highest of all with an average of 176.8 cm.

Treatment 6. Under this treatment the plants had a better growth than the control and can be compared with No. 3. They had an average height of 110.0 cm. At the booting stage, the vigor increased, but while it was better than those of No. 4, it was less vigorous than No. 5. They reached an average height of 171.3 cm.

Treatment 9. The growth of the plants in this treatment was only slightly better than that of the control. They had an average height of 98.8 cm. Toward the booting stage, there was rapid growth in height which reached 161.3 cm.

Treatment 10. The plants in this treatment were as vigorous as those of No. 9. They were slightly better in height, measuring 101.3 cm. At the booting stage, their growth slackened, and in vigor they appeared poorer than No. 9. They attained a height of 157.5 cm.

Treatment 11. The plants of this treatment showed a better growth than the control and can be compared with those of Nos. 3 and 7. They had a height of 120.0 cm. At the booting stage these plants were better than No. 10, averaging 160.0 cm. in height.

Treatment 12. The plants under this treatment also had a very good growth and can be compared with those of No. 4. They had an average height of 132.5 cm. At the booting stage, the plants in this treatment were better than those of No. 11. They attained an average height of 166.3 cm.

Treatment 13. The plants in this treatment had a good growth but not so good as those of No. 12; they may be compared with No.

11. Their average height was 117.5 cm. At the booting stage, the growth was the same as that of plot 10. They attained an average height of 160.0 cm.

Treatment 14. The plants in this treatment had a better growth than those of the control and can be compapred with No. 8; their average height was 102.8 cm. At the booting stage, the growth was better than those of No. 13, but the height was only 152.8 cm.

Treatment 15. The plants of this treatment were less vigorous than those of No 14, but had a better growth than the control. Their average height was 88.8 cm. At the booting stage, the growth was slightly better than No. 14, and reached a height of 146.3 cm. which was higher than the control.

Treatment 16. The plants under this treatment with and average height of 92.5 cm. can be compared with those of No. 15. At the booting stage, the growth was better than those of No. 15. They reached a height of 151.2 cm.

Treatment 17. The plants in this treatment and those of No. 16 had almost the same growth. They differed only slightly in height which averaged 95.0 cm. At the booting stage, the growth was also about the same as those in No. 16 with only slight difference in height. The plants of this treatment measured 152.5 cm. tall.

Treatment 18. The plants had a slightly better growth than either No. 16 or 17. They each had an average height of 96.3 cm. At the booting stage, the growth was not so good as that of the plants in treatments 16 or 17. The plants in this treatment produced culms of uniform size and attained an average height of only 148.8 cm.

Treatment 19. This treatment gave a good growth of plants. Tall culms were developed, averaging 113.8 cm. in height which in vigor can be compared with the plants of treatments 4 and 12. At the booting stage, these plants were better than those of No. 18. The plants averaged 158.8 cm. high.

Treatment 20. The plants of this treatment had a slightly better growth than those of No. 16. It was almost the same as the plants in No. 19 as to culm development. The height averaged 105.0 cm. At the booting stage, the plants were better than those of No. 18 but poorer than those of No.19. They attained a height of 148.8 cm.

Treatment 21. This treatment gave a slightly better growth than the control, and the growth can be compared with those of No. 15. They had an average height of 86.3 cm. At the booting stage, they were taller but less vigorous than the plants of No. 20. They attained an average height of 150.0 cm.

Treatment 22. The plants of this treatment had a growth about equal to that of the plants of No. 21. differing only in height. They had an average height of 88.8 cm. At the booting stage, the plants were better than those of No. 21. In height they averaged 153.0 cm.

Treatment 23. This treatment gave as good a growth as those of No. 22, but the plants were not so tall, as they averaged only 87.5 cm. At the booting stage, the plants were better than those of No. 22 though not so high. They had an average height of 151.3 cm.

Treatment 24. The plants of this treatment grew as well as those of Nos. 22 and 23, and were even taller (90.0 cm). At the booting stage, the plants had attained an average height of 157.3 cm. and were better than those of either Nos. 21, 22, or 23.

Treatment 25. The plants of this treatment grew as well as those of Nos. 21, 22, 23, and 24. They were slightly better than those of the control, with an average height of 88.8 cm. At the booting stage, the plants of this treatment had an average height of 143.8 cm. and were slightly better though not as tall as those of either Nos. 23 or 24.

DISCUSSION OF RESULTS

The nitrogen content of the soil during the four periods of sampling. It will be noted in chart 1, that the percentage of nitrogen obtained before flooding the soil varied from 0.153 as found in set No. 2, to 0.205 as found in set No. 20. The varying percentages of nitrogen may be due to the different treatments given to the soil during the first crop, and to the different amounts of nitrogen assimilated by the rice.

The nitrogen content of the soils at the second sampling (after flooding before fertilizing) was greater than when the soil was in the dry stage. This increase in the amount of nitrogen may be attributed to the fixation of nitrogen from the atmosphere by the microorganisms, especially of the genus *Clostridium.* Waksman (1927) concluded that *Clostridium,* which is abundant and universally distributed in the soil, fixed more nitrogen than *Azotobacter.* The latter thrives only when neutral or slightly alkaline aërobic conditions prevail in the soils.

The percentages of nitrogen obtained during this period did not vary much, except in set No. 4. which, because of the beneficial effect of green manures, influenced the degree of fixation by the micro-organisms. Waksman (1927) cited Kaserer who found that the beneficial action of humus was ascribed to its inorganic constituents as aluminum and silicic acid. Those treatments that contained low percentages of nitrogen during the dry stage of the soil had relatively large amounts of nitrogen fixed during the flooded condition. On the other hand, those treatments that had a high percentage of nitrogen in the dry stage had relatively small amounts of nitrogen fixed in the flooded stage. These results are irrespective of the treatments given to each set. There seems to be a point of equilibrium below which micro-organisms can fix nitrogen in the soil and above which they can not. This is clearly shown in chart 1.

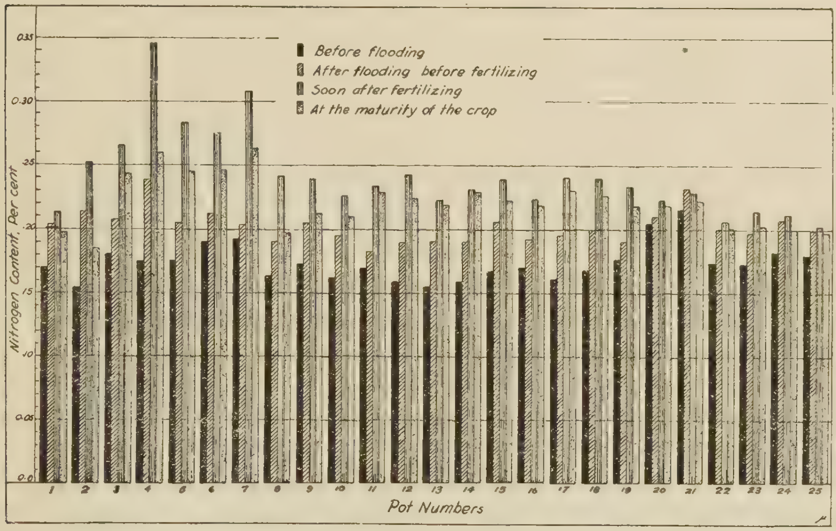

Chart 1.—Showing the total nitrogen content of the soil (average of four pots).

The third sampling, soon after fertilizing the soil, showed a further increase in nitrogen content. The large increase in nitrogen content in sets Nos. 2, 3, 4, 5, 6, 7, and 8 was due to the organic materials applied in the cans. Green manure had the greatest increase, 0.346 per cent, followed by a treatment consisting of 3 grams of ammonium sulfate and 200 grams of rice straw, and the next was set No. 5 which received 20 grams of calcium carbonate and 200 grams of grass straw. Treatment with 3 grams of $(NH_4)_2SO_4$ gave 0.234 per cent nitrogen. Set No. 7 gave 0.308, per cent; No. 19, 0.233 per cent; and No. 20, 0.223 per cent of nitrogen. With the 6 grams of $(NH_4)_2SO_4$, the amount of nitrogen was 0.247 per cent as found in treatment No. 12. Set No. 13 also received 6 grams of $(NH_2)_4SO_4$ in addition to 20 grams of $CaCO_3$ and gave 0.224 per cent of nitrogen. It will be noted that although 6 grams of $(NH_4)_2SO_4$ were added in set No. 13 as well as in set No. 12, the former contains a much lower percentage of nitrogen than the latter. This is explained by the action of the lime that was mixed with the ammonium sulfate in set No. 13. Fertilizers and soil amendments added, that did not carry nitrogen, increased the nitrogen content of the soil but to a less degree. The addition of 20 grams of lime ($CaCO_3$) increased the nitrogen content of the soil to 0.238 per cent. The addition of 40 grams increased the nitrogen content of the soil only 0.225 per cent. This result supports the belief that *Clostridium* works better in an acid than in an alkaline soil. Potassium chloride (KCl) treatments, as in sets Nos. 16 and 17 also increased the nitrogen content of the soil, to 0.224 and 0.240 per cent, respectively. Waksman (1927) said that potassium salts, provided they are added in small amounts in the soil, also favor the development of micro-organisms. On the other hand, sulfur and sodium chloride treatments gave about as much nitrogen content as the control. The application of NaCl, 10 grams per can, or 170 kgm. per hectare, seemed to show toxic effect upon the micro-organisms. According to Waksman (1927) the toxic effect of NaCl is apparent when 0.5 to 0.6 parts are present in every 100 grams of dry soil.

In all instances, except in sets Nos. 1, 2, 21 and 24, the nitrogen content during the last sampling was greater than that obtained when the soil was flooded and before the application of fertilizers and soil amendments. It will also be seen in chart 1 that the loss of nitrogen was greater in the sets treated with organic matter than in the sets treated with the inorganic substances. Lipman and Blair (1920) also found that the percentage of nitrogen retained in the soil was greater with the mineral nitrogenous matter than with the organic materials. They also found that more nitrogen was lost from the soil of plots treated with lime than from those without lime. Similar results were also obtained in sets Nos. 5, 6, 9, and 10. A relatively small percentage of nitrogen was lost from set No. 23. This was expected because the action of lime was offset by the sulfur present in that treatment. The action of $CaCO_3$ causes the rapid decomposition of the organic matter; furthermore, lime increases the pH value of the soil, and thus causes the nitrogen to be liberated as a gas. In the other sets treated with mineral materials, the decrease in nitrogen content was very small, in spite of the fact that the rice plants were planted in the soil. In their experiment on the availability of nitrogenous fertilizers, Lipman and Blair (1920) found from analysis of the soil upon which a wheat crop was grown in rotation with corn oats and timothy that the nitrogen content of the soil showed slight gains. They claimed that such gains cannot continue indefinitely. There comes a time when "a point of equilibrium" is reached, higher or lower, according to the soil conditions, where further gains are balanced by losses so that the nitrogen content remains constant.

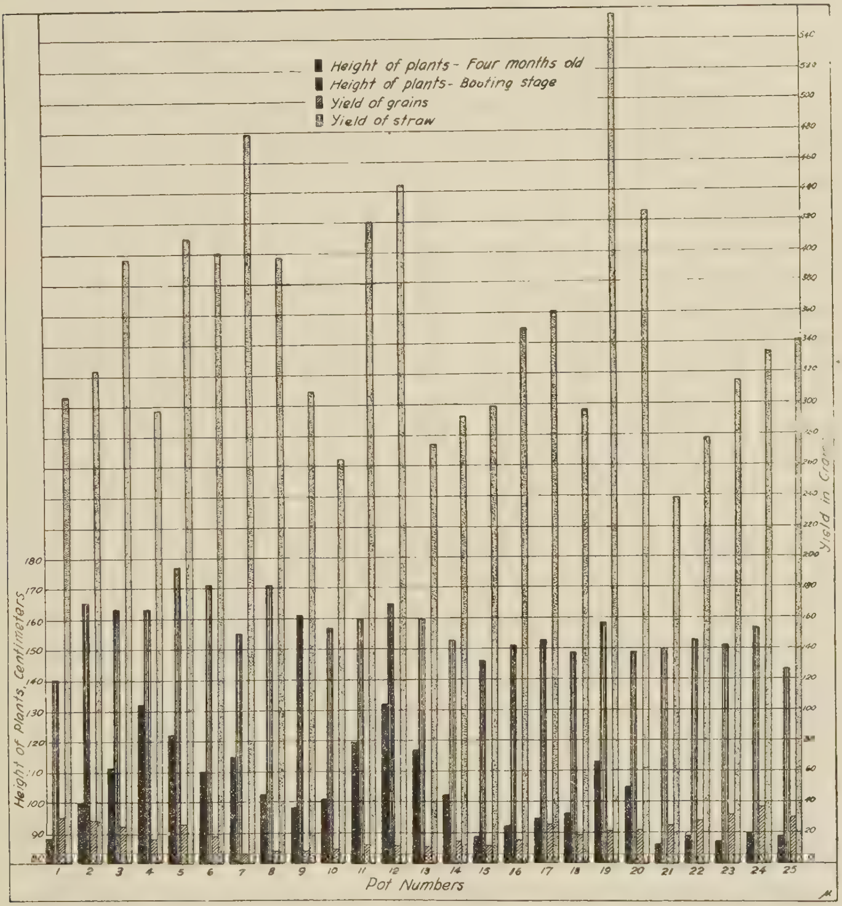

Chart 2.—Showing the height and yield of Ramai rice.

Relation between the total nitrogen and the growth and yield of Ramai rice. The growth of the rice may be measured by the height of the culms. The relation of the height to the total nitrogen content of the soil after fertilizing is clearly shown in chart 2. There seems to be a direct relationship between the nitrogen content of the soil and the growth of the four month-old plants. It is clearly shown in the chart that where the nitrogen content was high, the growth was also high, and vice versa. However, there were three sets of treatments in the experiment; namely, Nos. 14, 15, and 16, that for some reason are exceptions to the statement. Except for sets Nos. 3, 4, 5, 7, 8, 14, 15, 16, 18, 19, 21, 22, 23, and 24, the height of the plants taken during the booting stage also showed the same relationships. As to the height of the plants, those sets with organic matter and $(NH_4)_2SO_4$ treatments gave the highest growth, and these were also the plants that gave good development of culms when young. When the plants approached maturity, most of the culms died, leaving only a few main stalks to flower.

No direct relationship can be established between the nitrogen content and the yield of rice. The percentage of total nitrogen obtained in this experiment includes both the available and the non-available forms. In some instances, where relationships seemed to exist, the author would not attempt to establish such correlation. This condition was also found by Trelease (1918).

The yield from the first crop (December 30, 1933) was much greater than that of the second crop. This decrease in yield may be attributed to three causes; namely, (1) great disturbance of the root systems during the taking of samples, (2) the frequent and violent storms that occurred during the period of growth and, (3) the planting of the crop was out of season. The yield in the second crop showed that the different fertilizers and soil amendments had a constant effect upon the yield of the grain. The yield of palay in the first crop, as shown in table 3, varies from 75.1 grams. as found in set No. 3, to 33.3 grams in set No. 11. In sets Nos. 1, 2, 3, 4, 5, 6, 10, 16, 19, 20 and 22 the yield was more than 50 grams. In the second crop, the yield of palay, as shown in table 3, varied from 35.5 grams, in set No. 24, to 7.5 grams in set No. 7. A yield of more than 19 grams was obtained from each of the following sets: Nos. 1, 2, 3, 5, 6, 17, 18, 19, 20, 21, 22, 23; 24; and 25. This yield is shown in chart 2. The average yield of the first and second crops was low in sets Nos. 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16. In all sets treated with 3 or 6 grams of $(NH_4)_2SO_4$ applied alone or mixed with other materials, the yield of grains was lower than that of the control. The yield from potassium salt treatments was greater than that of the phosphorus salts. Greater yields were obtained when the potassium and phosphorus salts were mixed with the nitrogen, than when the materials were applied alone. Similar results were obtained by Borja and Torres (1930). The application of lime in sets Nos. 5, 6, 9, 10, and 13 did not give an appreciable yield greater than the control. Lime mixed with organic matter gave a higher yield of grain than when it was applied alone to the soil. In set No. 23, 20 grams of $CaCO_3$ mixed with 1.5 grams of sulfur gave a yield higher than the control. With the sodium chloride, small applications prove more effective than larger amounts. Set 24 of the second crop gave the highest yield of grain.

The yield of straw from the second crop varied considerably; that is, from 556.3 grams to 239.0 grams. The yield of the straw was probably abnormal because the culture lasted 10 months instead of 7 months which is the regular length of time for maturity of this variety of rice. The greatest yield of straw was obtained from set No. 19, to which was applied a mixed fertilizer containing nitrogen, phosphorus, and potassium. Set No. 7, treated with 3 grams of $NH_4)_2SO_4$ and 200 grams of rice straw gave the second best yield of straw. Set No. 21 treated with 0.75 gram of sulfur gave the lowest yield followed by set No. 10 which was treated with 40 grams of lime. The initial effects of the fertilizers and soil amendments did not produce any correlation between the yield of straw and grains. This is shown in chart 2 Trelease (1918) and Soriano[3] arrived at a similar conclusion in their investigation on the growth of rice in treated soils.

SUMMARY AND CONCLUSIONS

1. The nitrogen content of the Nanhaya clay was determined during the four different stages in the culture of lowland rice.

2. There was a low nitrogen content, ranging from 0.153 per cent to 0.205 per cent, when the soil was in dry condition.

3. There was an increase in the nitrogen content of the soils when the cans where flooded. The percentage of nitrogn during

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[3] SORIANO, ANTONINO M. The effect of fertilizers added to soils in pots upon the yield of straw and grain of an upland rice. (Thesis presented for graduation with the degree of Bachelor of Agriculture from the College of Agriculture. 1922. Unpublished.)

this period did not vary much. It ranged from 0.191 to 0.238 per cent.

4. The increase in the amount of nitrogen was attributed to the fixation of atmospheric nitrogen by micro-organisms.

5. With the amounts of fertilizers and soil amendments applied in the cans, higher percentages of nitrogen were obtained from the soils of the sets that received organic materials than from those that received inorganic ones.

6. Soil amendments, like sulfur and sodium chloride, had little effect upon the nitrogen content of the soil.

7. Larger amounts of nitrogen were lost from the soil treated with organic matter than from that treated with inorganic materials.

8. The amount of nitrogen in the soil influenced the vegetative growth of the rice four months old.

9. Higher yields of grain were obtained from soils treated with organic matter and mixed fertilizers containing ammonium sulfate than those that did not contain any nitrogenous materials.

10. The amount of lime, ammonium sulfate, monocalcium phosphate, and potassium chloride applied, failed to produce any increase in the yield of grains.

11. Heavy yields of straw were obtained from treatments with complete fertilizers.

12. This form of experiment should be continued using larger amounts of the different fertilizers and soil amendments, and lower amounts of the organic matters and sodium chloride, and also increasing the number of plots in a set.

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A COMPARATIVE STUDY OF RICE BRAN AND CORN BRAN AS FEEDS FOR GROWING AND FATTENING PIGS[1]

ISIDORO M. AGUANTA

Corn is one of the most important crops in the Visayan Islands. It is abundantly grown in the provinces of Cebu, Leyte, Oriental Negros and in the Cagayan Valley where it is the staple food of the people. In the preparation of corn for human consumption, a by-product called *tahup sa mais* (Visayan) or *tahup* for short is produced. This corn by-product is an important feedstuff for horses, hogs and chickens in regions where corn is the staple. The feeding value, however, for certain classes of animals and for specific purposes has not been determined experimentally.

Review of literature

Allas (1924) in his experiment comparing rice bran, corn, and copra meal for growing pigs found that rice bran gives the best result of the three feeds as a concentrate supplement to sweet potato vines. He found that corn alone is not a good supplement. The rice bran and corn mixture, although better than corn alone, did not give as good returns as the rice bran alone.

Bautista (1918) stated that rice bran was a more efficient feed than shelled corn. The efficiency of rice bran over shelled corn was increased when the pigs were put on cowpea pasture.

Tolentino (1935) compared tahup sa mais with corn meal and rice bran in rations for growing chicks. He found that tahup is much better than rice bran when used singly supplemented with 20 per cent shrimp meal, but decidedly inferior to corn meal. The combination of rice bran and corn meal is markedly better than tahup alone or a combination of rice bran and tahup. It required 4.49 kgm. feed to produce a kilogram live fowl in the corn meal lot; 4.9 kgm. in the tahup lot; 4.49 kgm. in the corn meal-rice bran lot; and 5.66 kgm. in the tahup-rice bran lot.

Fernandez (1934), in his experiment on the feeding value of tahup and fine rice bran in rations for egg production concluded that these two feeds have about the same feeding value, as regards percentage of egg production, size of eggs, and feed consumption, but their combination proved better than either. There was a higher mortality among the birds on the rice bran ration than in those on the tahup ration. On the other hand there was noted a higher percentage of fertile and hatchable eggs among hens on the rice bran ration than on the tahup sa mais ration.

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[1] Thesis presented for graduation, 1934, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture, No. 512; Experiment Station contribution No. 1155. Prepared in the Department of Animal Husbandry under the direction of Dr. Mariano Mondoñedo.

Object of the present work

The object of the present work was to determine the feeding value of tahup compared with rice bran for growing pigs.

Time and place of the work

The experiment was begun on April 2, 1933 and closed on November 5, 1933, covering a period of 217 days. The work was conducted in the Division of Swine, Department of Animal Husbandry, College of Agriculture, Los Baños, Laguna.

Materials

Weanling pigs. Twelve Berkjala weanling pigs were used. They were about fourteen weeks old at the beginning of the experiment.

Feeds used. The feeds used in this experiment were corn (Calauang Yellow Flint), standard rice bran, tahup sa mais (from corn of the Cebu White Flint variety), copra meal and shrimps.

Tahup sa mais, the feed under consideration is not exactly corn bran, but a by-product in the preparation of "rice of corn", a literal translation of the product of corn, commonly called in the Visayas, *bugas sa mais.* It is composed of the hull or bran, part of the horny endosperm, the germ and the tip caps of the corn kernel. Tahup is obtained by winnowing the ground shelled corn, separating the lighter parts (tahup) from the "rice of corn", the product. It corresponds with the American product *corn feed-meal*, sometimes marketed also as *corn meal.*

The chemical analysis of the feeds compared is shown in the following table:

Chemical analysis of feeds compared[a]

FEEDS	MOISTURE	FAT	ASH	PROTEIN	CRUDE FIBER	CARBOHYDRATES	CALORIES PER 100 GRAMS
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	
Tahup sa mais ..	11.67	4.95	3.25	9.69	5.39	66.05	357.00
Rice bran	9.20	13.89	10.11	12.38	9.72	44.70	363.21

[a] Analyzed by the Chemistry Department, College of Agriculture.

The current prices of the feeds at the time the experiment was conducted were as follows:

Corn	4.4	centavos	per	kilogram
Rice bran	3.9	”	”	”
Tahup sa mais	4.2	”	”	”
Copra meal	3.9	”	”	”
Shrimps	11.8	”	”	”

Rations. To form the rations used in this experiment the feeds were mixed in the proportion shown below in tabulated form:

(1) Ration for the first 70-days

(Growing ration, pigs 14 to 24 weeks old)

Lot	I	II
Corn	15	15
Rice corn	60	00
Copra meal	20	20
Tahup sa mais	00	60
Shrimps	5	5

(2) Ration for the second 70-days

(Growing and Fattening, pigs 25 to 35 weeks old)

Lot	I	II
Corn	20	20
Rice bran	60	00
Tahup sa mais	00	60
Copra meal	17	17
Shrimps	3	3

(3) Ration for the third 70-days

(For fattening, pigs 35 to 45 weeks old)

Lot	I	II
Corn	25	25
Rice bran	60	00
Tahup sa mais	00	60
Copra meal	15	15

Mineral mixture used. One kilogram of the following mineral mixture was added to every 100 kilograms of the ration mixture given:

45 parts cob charcoal
45 parts common salt
10 parts slaked lime

100 parts

Methods

Allotment of pigs. There were two lots of pigs in the experiment, six pigs in each lot. In alloting the pigs, special care was taken to have the two lots as nearly as possible equal in size, age, sex and condition.

The general plan of the experiment was to make no reallotment of the pigs throughout the 210 days of feeding trial, although determination of results were to be taken at the end of each 70-day period. Owing to the fact, however, that in the course of the first 70-day period some of the pigs in both lots became sick, and two died in lot I, reallotment had to be made before the second 70-day period was begun. The sick pigs were discarded and four new pigs of the same age were added to the eight healthy pigs remaining. The new pigs were placed under preliminary test for seven days. The pigs were about 25 weeks old when the second 70-day period of feeding was begun. Because the pigs in both lots made steady gain during the second 70-day period, the same lots of pigs were kept to the third 70-day period as originally planned.

b. Feeding. During the first 70-day period, the pigs were allowed a full grain ration, and camote soilage *ad libitum*. In the second 70-day period the pigs were allowed full rations and given access to the *Calopogonium* pasture. In the third 70-day period they were dry lot fed.

c. Weighing. Throughout the feeding trials the animals were weighed weekly. The initial weights were the average for three consecutive days. The final weights were obtained in a similar manner

d. Care and management. Throughout the feeding trials all the pigs were herded together in an inclosure of about one-sixteenth of a hectare which was bare of vegetation. Acacia trees growing along one side of the fence afforded shelter for the pigs. During the second 70-day period the pigs in both lots were given access to a *Calopogonium* pasture. At feeding and watering time and during inclement weather the pigs were driven to the hog house. The feeds were given between 6:00 and 7:00 a. m., and 5:00 to 6:00 p. m. At noon the pigs were given drinking water and bathed.

SUMMARY OF RESULTS

First 70-day period	*Lot I*	*Lot II*
Average initial weight in kgm.	12.32	12.28
Average final weight in kgm.	38.50	24.97
Average daily gain per pig in kgm.	0.30	0.18
Feed consumed per kilogram gain	5.53	4.47
Feed cost per kilogram gain in centavos	24.20	20.30

Second 70-day period	*Lot I*	*Lot II*
Average initial weight in kgm.	41.53	41.60
Average final weight in kgm.	70.31	66.83
Average daily gain per pig in kgm.	0.41	0.36
Feed consumed per kilogram gain	6.12	6.19
Feed cost per kilogram gain in centavos	25.90	26.70

Third 70-day period		
Average initial weight in kgm.	70.28	66.83
Average final weight in kgm.	104.53	95.05
Average daily gain per pig in kgm.	0.49	0.40
Feed consumed per kilogram gain	5.83	6.71
Feed cost per kilogram gain in centavos	23.40	28.20

RESULTS

In addition to the summary of results given above the following observations should be noted.

Throughout the feeding trial of 210 days the pigs in lot I (rice bran) consumed more feed and in less time than did those of lot II (tahup sa mais).

First 70-day period. The pigs in lot II were observed to eat more of the soilage than did those of lot I. They went after it greedily. The pigs in lot I ate also the camote soilage but they took time to eat without fighting for it. On April 15, 1933, pig No. 2145 of lot I began to decrease in weight and fell off in condition, showing symptoms of parasitic infestation. It was treated with a vermifuge, (oil of chenopodium). It did not recover and died April 17, 1933. Post-mortem examination revealed that the pig was infested heavily with ascaris. Pig No. 2167 of the same lot gradually lost in weight from May 21 until it died on May 30, 1933. This pig was also treated for ascaris. Post-mortem examination revealed heavy infestation with whipworm. On May 7, 1933, pig No. 2169 of lot II began to decrease in weight. Pig No. 2152 of the same lot also showed loss in weight on May 14, 1933. These animals showed symptoms of parasitic infestation. In spite of the treatment they continued to decrease in weights until the end of the first period. During this period of feeding the four pigs in lot I were uniform in size and in good condition. There was no sign of stunted growth. The pigs in lot II lacked uniformity in size and in condition.

Second 70-day period. The pigs in both lots were all healthy and made fairly good gains.

Third 70-day period. The gains made by both lots were fairly steady with lot I still leading. Throughout the period the pigs in both lots were in good condition.

As criteria of the results obtained, the amount or rate of gain per day, the feeds consumed per kilogram gain, and the cost of feed required to make a kilogram gain are used.

DISCUSSION OF RESULTS

First 70-day period. It may be noted in the summary of results that lot I pigs on the rice bran ration made an average daily gain of 0.30 kilogram, and the lot II pigs on the tahup sa mais ration made an average gain of 0.18 kilogram. Compared with lot I, lot II was only 60 per cent efficient. This may be expected, considering the fact that rice bran contains more proteins, fats, and ash than tahup. It may be mentioned that lot I pigs consumed more feed in less time than did lot II pigs, showing that the rice bran ration was more palatable and probably more suitable for the pigs at this age than the tahup sa mais ration.

The elimination of the two unthrifty pigs in lot I by death due to ascariasis increased the average gain of the lot at the end of the period. On the other hand, the presence of the two unthrifty pigs affected with ascaris up to the end of the experiment considerably decreased the average gain of lot II. When the average gain in weight of the four healthy remaining pigs in lot I was compared with that of the four healthy pigs in lot II during the period it was found that the lot I pigs made 25.6 kilograms and the lot II pigs, 18.6 kilograms. Still the tahup sa mais ration was only 73 per cent as efficient as the rice bran ration.

On the basis of feed consumption per unit of gain, however, the lot I pigs needed 5.53 kilograms of feed and lot II, 4.47 kilograms feed to make a kilogram gain. This would seem to show that the tahup ration was superior to the rice bran ration. This appeared not to be the case, however, as it was observed in the course of the trial that the lot II pigs finding their ration not so very palatable went after the camote soilage more avidly than did the lot I pigs. The pigs in lot I were more satisfied with their rice bran ration and were less eager for the camote soilage.

From the point of view of the feed cost for a given unit of gain, lot I required ₱0.24 worth of feed to make a kilogram gain, and lot II required ₱0.20. This difference was of course expected because actually lot II required less feed for a kilogram gain than lot I.

Second 70-day period. By reference to the summary of results it may be seen that lot I (rice bran) pigs made an average daily gain of 0.41 kilogram and the lot II (tahup sa mais) pigs made 0.36 kilogram, which was only 88 per cent of the gain of lot I.

From the viewpoint of feed consumption for a given unit of gain weight of the pigs, there was very little difference between lot I and II. Lot I required 6.12 kilograms and lot II, 6.19 kilograms of feed to make a kilogram gain. This result shows that tahup had practically the same feeding value as rice bran, when used in the proportion of the rations given for pigs of this age. The pigs had access to Calopogonium pasture but they neither touched nor ate it.

Comparing the cost of the feed consumed for the gains made, lot I consumed feed worth ₱0.26 to make a kilogram gain and lot II, ₱0.27.

Third 70-day period. Again, it may be seen in the summary of results that lot I (rice bran) pigs made an average daily gain of 0.49 kilogram and pigs in lot II (tahup sa mais) made an average daily gain of 0.40 kilogram, which was only 82 per cent of the gain made by lot I.

From the viewpoint of the feed consumed per kilogram gain, lot I required 5.83 kilograms and lot II, 6.71 kilograms. The pigs were 35 to 45 weeks old. In other words the tahup ration was only 87 per cent as good as the rice bran ration.

The cost of feed consumed per kilogram gain was ₱0.23 for lot I and ₱0.28 for lot II.

SUMMARY AND CONCLUSIONS

The results obtained in this study may be summarized as follows:

1. Basing calculations on the amount or rate of gain made for a given period, tahup sa mais as a substitute for rice bran in the ration used in the first 70-day period of the test was only 61 per cent as efficient as rice bran for pigs 14 to 24 weeks old and allowed camote soilage.

2. For pigs 25 to 35 weeks old on limited pasture, taking the rate of gain as a basis of comparison, tahup in the ration given in the second 70-day period was only 88 per cent as good as rice bran.

3. Taking the rate of gain as a basis for comparison for pigs 35 to 45 weeks old on dry lot feeding, tahup was only 82 per cent as efficient as rice bran.

4. From the viewpoint of economy in feed for a given unit of gain, in the first 70-day period, lot I pigs required 5.53 kilograms of feed worth 24.2 centavos, and lot II pigs required 4.47 kilograms of feed worth 20.3 centavos for every kilogram gain. In the second 70-day period lot I required 6.12 kilograms of feed worth 25.9 centavos, and lot II pigs required 6.19 kilograms worth 26.7 centavos for every kilogram gain. In the third 70-day period, lot I pigs required 5.83 kilograms of feed worth 23.4 centavos, and those of lot II required 6.71 kilograms of feed worth 28.3 centavos for every kilogram gain.

5. Under the conditions in which the experiment was conducted, lot I pigs made an average daily gain of 0.40 kilogram and lot II pigs made 0.31 kilogram during the whole 210-day feeding trial.

6. From the viewpoint of feed consumed to make a kilogram gain for the whole 210-day period lot I required 5.86 kilograms worth 24.5 centavos and lot II, 6.06 kilograms worth 25.1 centavos.

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ABSTRACT[1]

Cultural and commercial studies of indigo in Pangasinan and in the College of Agriculture. DOMIMGO E. BANDONG. (*Thesis presented for graduation, 1935, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 513; Experiment Station contribution No. 1156.*)— The objects of this work were: (*a*) To study the indigo industry in Pangasinan with respect to methods of culture and manufacture of indigo, method of operating the indigo factories, and the process and cost of dyeing the cotton yarn, (*b*) to carry on a test culture of indigo plants and tests in manufacture of indigo at the College of Agriculture. The author conducted his investigation in the towns of Mañgaldan, Mapandan and San Jasinto, Pangasinan by interviewing each dye factory owner and by giving to him and his tenant farmers a questionnaire with the request that they answer the questions as fully as possible. Then he carried on an experiment on indigo culture and manufacture at the College of Agriculture. The author summarizes the results he obtained as follows:

1. Indigo is planted in Pangasinan by broadcasting the seeds between the trees in coconut plantations. Thinning, weeding and cultivation are not usually practiced by the farmers. In the College of Agriculture the indigo seeds were planted in hills 30 centimeters apart and in furrows 50 centimeters apart.

2. The usual yield per hectare planting under ordinary method in Pangasinan is about 16,000 kilograms of fresh indigo plants and the same area of ratoon crop gives 10,666 kilograms of fresh indigo plants. At the College of Agriculture a plant crop gave about 1,600 kilograms of fresh indigo plants per hectare and a ratoon crop, about 800 kilograms.

3. Of three methods of manufacturing indigo paste tried in the College of Agriculture, the boiling method gave the best result.

4. Before the introduction of synthetic indigo, the Pangasinan farmers manufactured liquid indigo, indigo powder and cake but at the present time they manufacture only liquid indigo.

5. The dyeing of yarn in Pangasinan is done by washing it first in water then soaking it in the dye and then washing it again

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[1] Abstract prepared as part of the required theme work in English 3a, College of Agriculture.

in water three times or until the desired shade of color is obtained. Then the yarn is hung on bamboo poles to dry in the sun.

6. A dyer receives from 0.12 to 0.75 a day, depending upon his skill and experience.

7. A capital of from ₱40.00 to ₱500.00 is sufficient to start a cotton dye factory in Pangasinan.

8. The net profit of a dye factory owner in this province ranges from ₱12.67 to ₱225.00 a month. The usual profits average from ₱57.24 to ₱77.12.

9. The sales vary from ₱27.26 to ₱618.12 a month, the average being from ₱147.24 to ₱196.00.

—*Abstract by Bonifacio Puntalba*

A REVIEW: TROPICAL PLANTING AND GARDENING, WITH SPECIAL REFERENCE TO CEYLON,[1] [2]

Although this book is primarily intended for Ceylon farmers it may serve as a handbook and guide to planters and gardeners of other tropical countries, for example, of the Philippines which is at present experimenting with new tropical crops.

Part I presents a readable treatment of the influence of climate and soils on the growth of the plants. It gives a simple, clear and concise discussion of plant-life, reproduction, nutrition, use of manures, fertilizers, green-manuring, mulching, cover-crops, soil operations, tillage, drainage, crop-rotation, propagation, grafting, budding, plant breeding, cultural operations, planting, shading, and pruning. Other subjects such as garden adornments, labels, implements, laying out of gardens, choice of site, preparation of ground, hedges, paths, borders, lawns, plant-sheds, veranda-gardening, etc. are also dealt with.

Part II discusses the following subjects: beautiful trees of the tropics, selected ornamental plants for the tropics, ornamental orchids, pot-plants, ferns, selected palms, etc., selection of ornamental plants, trees, suitable for different altitudes in the tropics; shade, wind-belt, timber, fuel trees, railway, school and rest-house gardens and agri-horticultural shows.

Part III deals with tropical fruit culture, and gives descriptions of the characteristics of fruits, vegetables, spices, condiments and seasoning herbs suitable for tropical and sub-tropical climates. The principal features connected with their natural occurrence and their cultivation in plantations are also included, but rather brief.

Part IV presents simple descriptions of important tropical plants producing beverages, edible products, drugs, medicine, masticatories, poisons, oils and vegetable fats, rubber, gutta, gums, resins, fibers, rattan or canes, silk, dyes, tans, pasture and fodder. Their cultivation in plantation and the methods of preparing the products for market are briefly described. More and up to-date references to fiber and oil plants could have been included.

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[1] H. F. Macmillan. 1935. Tropical planting and gardening with special reference to Ceylon. x + 560 p., 482 fig. London: Macmillan and Company, Limited, St. Martin's Street.

[2] General contribution from College of Agriculture No. 538.

Part V includes a descriptive list of perfume-yielding plants, selected bee plants, rare fruit trees, seed trees, insectivorous and myrmecophilous and rare sacred trees. Enemies and friends of gardens and estates, pests and diseases, weeds, and their methods of control are also discussed. Other subjects such as transport and packing planting materials for shipment, storing seeds, useful references; measuring land, timber, recipes for making jams, jellies are described. Tables of weights and measure, calendars of work for Ceylon and a short agricultural glossary are given at the end of the book.

No bibliography is given and the author has not included more recent work in many crops. This oversight on the part of the author makes some of the chapters, especially on oil and fiber plants, rather unsatisfactory. Families and local names of many plants which are also grown in the Philippines are misquoted. The descriptions of a few plants and information concerning their culture are too abridged to be useful especially in the hands of a layman for whom the book is intended; otherwise the book as a whole would be a fair guide to crops even for the Philippines.

PEDRO A. DAVID
Of the Department of Agronomy.

COLLEGE AND ALUMNI NOTES

The following students were on the honor roll for the first semester, 1936-37, according to a report released by the Secretary of the College: José R. Velasco, Lorenzo P. Zialcita, Jr., Ian Khambanondha, Manuel V. Quisumbing, Rodolfo M. Madlangsacay, Florendo R. Naanep, Fidela Ilag, and Amando M. Dalisay.

At a recent general meeting of the Student Body, the officers elected for the second semester were: president, Miguel Manresa, Jr.; vice-president, Lorenzo P. Zialcita, Jr.; secretary, Manuel V. Quisumbing; treasurer, Gavino Rotor, Jr.; director of the College orchestra, Cecilio Pangga; representatives to the U. P. Student Council, Trinidad Q. Alconcel and Miguel Manresa, Jr.; and representative to the Philippine Collegian, Amando M. Dalisay.

A program sponsored by the student council of the College of Agriculture was held in the Baker Memorial Hall on December 12, the main feature of which was the presentation to the College of a large portrait in oil of Professor Emma Sarepta Yule.

The following papers were read at the meeting of the Los Baños Biological Club on November 19:

Mr. Justino Seguerra—Diameter increment of trees in the natural stand at Maquiling National Park.

Dr. F. M. Fronda and Mr. D. D. Clemente—Studies on the physical qualities of the hen's egg: V. Age and seasonal changes as factors in the rate of deterioration of the interior quality of Los Baños Cantonese eggs. (This paper appears in the present issue.)

By a recent action of the University authorities, the name of the Department of Plant Physiology of this College has been changed to Department of Agricultural Botany.

SCIENCE AND MAN POWER[1]

The advances made by science are so patently responsible for the progress of the world during the last century that few are now inclined to question the efficacy of the methods of science and the value of the work of scientists. Any success, however, invites imitation and we witness not infrequently the sorry spectacle of dilettantes and even charlatans parading under the banner of science, and incidentally degrading it. While it is next to impossible to draw a sharp demarcation line between the genuine and the spurious in every instance, the standards set by the leading scientists of a country or region should make it impossible for charlatanism to successfully pass for science. In other words, where true science prevails, pseudo-science should perish; or where the public can secure accurate information from serious-minded scientists, it should not readily accept theories, conjectures, suppositions, and other figments of the imagination as scientific facts.

As in practically every other calling except unskilled labor, before one can engage in it, one has to undergo a period of study or preparation so that he may be able to use as working tools the knowledge and experience painfully acquired by his predecessors. Likewise in science, a period of preparation is necessary before one may follow it as a vocation or an avocation. The degree of this preparation is directly related to the advances heretofore made in the particular branch of science one has in mind. The mass of knowledge that has accumulated in some lines is now so vast that only specialists can hope to master the latest information on any particular subject. As a matter of fact, it is because of this that specializations have developed. Gradual progress is being made in every branch of science towards facilitating the acquisition of the basic knowledge that serves as the foundation for those in training for the vocation, but the accumulation of information goes so much faster that any success attained towards simplification lags far behind.

While there is no limit to the speed of thought, its transmission from mind to mind unfortunately must depend on contact, which

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[1] General contribution No. 539.

THE PHILIPPINE AGRICULTURIST, VOL. XXV, NO. 9, FEBRUARY, 1937.

often requires the prosaic methods of mechanical travel. Attendance in formal classes, personal conversations, conferences, presence in scientific meetings, conventions, and the like may be the vehicles of contact. The printed page in the form of journals, monographs and treatises furnishes valuable indirect and detailed contact, but neither contact nor the printed page can replace the other. They supplement one another.

The Philippine Commonwealth and the Filipino people are making a bid for active participation in world affairs. They appreciate the benefits that can be derived from progressive science; they should be prepared to meet the price that must be paid for the adequate training of their scientists. Isolated by great expanses of water as the country is, the problem of effecting close contact with nations wherein science is active and progressive must be met squarely. We cannot permit distance to wall us in science under penalty of becoming backwards.

In the College of Agriculture, we have realized from the beginning the necessity of equipping our faculty with the knowledge from which other scientists start before they feel competent to face independently local problems. After a period of rigid undergraduate training a young man is sent to the best educational centers of the world dedicated to the particular line of work he is interested in, that he may imbibe knowledge from the recognized leaders of his field of endeavor. In this manner, he not only acquires information but also confidence that only personal contact with the masters can give. With the care exercised in the first place in the selection of the individuals for training, the results have been invariably satisfactory, and the record of the institution in science bears witness to the degree of success attained.

The plan followed is locally known as the pensionado, or fellowship, system. Promising graduates are appointed to temporary positions in the faculty and taken in hand for their specialized training by older members of the faculty, performing in the meantime routine service in an assistive capacity. Upon attaining a degree of proficiency and demonstrating genuine interest and natural inclination towards the subject matter, they are sent abroad for advanced graduate work. Upon returning from this period of training, usually equipped with a doctor's degree, they are taken in as regular members of the junior faculty. Of late years due to the economic depression, it has not been possible to follow this program, and continuity has been broken. Now that better times are on and normal existence and growth can be resumed, the plan should be renewed if the institution and the country are not to suffer from inadequate scientific work.

Another alternative that insures contact with scientific leaders is to invite them to come to the Islands. Experience has shown, however, that their stay in our country is usually too brief to permit them to fully grasp our problems. While one may view this method as the more economical inasmuch as one man may come to influence many local workers, actually most of this is wasted effort as few are adequately prepared to profit from the stay of such specialists. It is far better that a local young scientist meet several leaders in a number of countries than for one such leader to scatter his efforts attempting to train a horde of immature or unprepared students.

In science the right man properly trained is still the biggest thing.

B. M. GONZALEZ
Dean, College of Agriculture

A HISTORICAL SKETCH OF COLLEGIATE EDUCATION IN AGRICULTURE IN THE PHILIPPINES[1]

By LEOPOLDO B. UICHANCO
Of the Department of Entomology

WITH TEN TEXT FIGURES

Owing apparently to the stimulus to agricultural development which followed the establishment of the Real Sociedad Económica, plans for agricultural instruction at last began to be considered in the Philippines, after some two and a half centuries of Spanish colonization. On February 26, 1821, a royal decree authorized a professorship of agriculture in Manila. However, despite the offer of the Sociedad Económica to pay the professor's salary of 250 pesos a year, the school did not materialize. At least two other fruitless efforts were made, one on November 14, 1822, and another in 1845. Finally, on September 13, 1858, through the energy of Governor Fernando de Norzagaray y Escudero, who had assumed his post less than a year previously, there was established a botanic garden in its present site at Calle Arroceros, Manila, and with it a school of agriculture. The personnel consisted of one professor of botany, two teaching horticulturists, and ten laborers who were selected from among the students of agriculture. That the school lasted at least three years is shown by the fact that a royal decree of May 29, 1861, placed the school of agriculture under the central government and subject to the supervision of the Sociedad Económica. Despite all these measures, however, the school apparently did not live long.

A couple of decades later, on July 2, 1889, a new school of agriculture opened its doors in Manila. Although called "escuela agrícola," it was, judging from its schedule of courses, presumably of collegiate grade. The order for its creation had been issued by royal decree on November 29, 1887. There must have been at that time an unusual zeal for agricultural revival, such as we witness periodically in our own time, for almost simultaneously, two other entities, the University of Santo Tomás and the Ateneo Municipal (now Ateneo de Manila) organized agricultural curricula.

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[1] General contribution No. 540.

The enrollment of the new school was not large; it was reported that during its first year "33 scholars matriculated in the course for skilled farmers and 22 in the course for overseers." That there was not a sufficient demand for agricultural courses in those days is indicated by the fact that the school apparently lasted just long enough to hold one commencement. Agricultural instruction in the Ateneo and in Santo Tomás suffered a similar fate shortly after.

All these efforts at agricultural instruction were dismissed by the historian James A. LeRoy as "a pet idea of the spasmodically flourishing Liberal ministries of Spain, which inspired some reams of official reports." He informs us, moreover, that "technical education got little beyond the decree stage in the Philippines prior to American occupation."

Later plans for agricultural instruction

The succeeding decade, owing to the revolution against Spain from 1896 to 1898 and the uprising against the American army of occupation from 1899 to 1901, was too unsettled to effectively carry out in this country any kind of educational work. It is worthy of note that the Philippine revolutionary government's educational program in 1899 was to have made instruction in agriculture the only state obligation in addition to the public primary schools. The agricultural courses proposed were of three kinds: (1) superior, for training "ingeniero agrónomo"; (2) professional, for training agricultural experts (*peritos agrícolas*); and (3) elementary, for overseers (*capataces*). These plans, however, were never carried out.

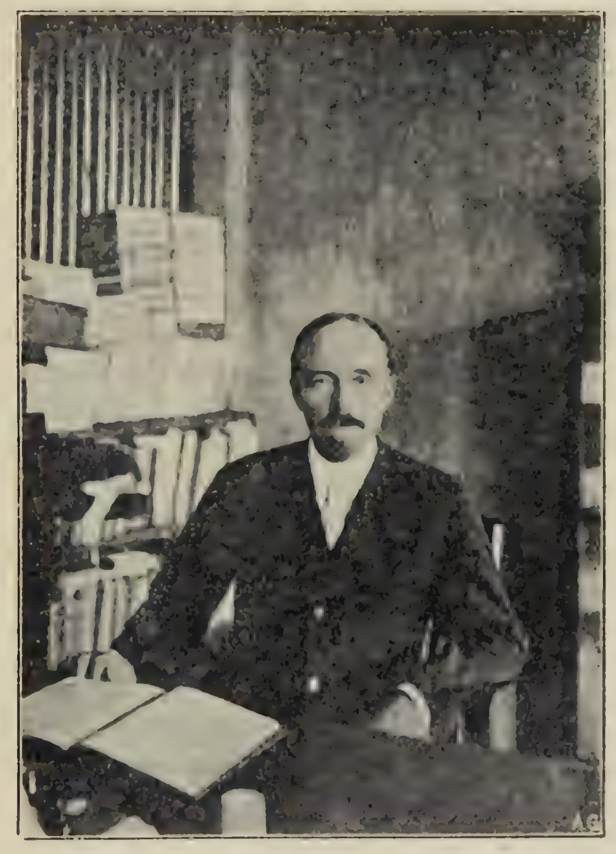
The American army, in the meantime, adopted from the beginning a policy of general education of the inhabitants. According to Jernegan, General McArthur, in recommending a large appropriation for school purposes, said: "This appropriation is recommended primarily and exclusively as an adjunct to military operations calculated to pacify the people and to procure and expedite the restoration of tranquility throughout the Archipelago." In 1899, plans were beginning to be considered by the new régime for the founding of an agricultural college as a part of the main educational program for the Philippines. These plans culminated in the year following in the passage by the Philippine Commission of Act No. 74, which provided for the establishment of an agricultural school and experimental farm to be located at La Granja Modelo in Negros Occidental. The sum of ₱30,000 was appropriated for this project. Apparently, the only reason for choosing La Granja was that there was there a 2,000-acre piece of Government-owned land, which had to be used in some way. Significant, however, was the view expressed even at that time that "its inaccessibility has suggested that it might not be difficult to find a more advantageous site for the school and one that might be readily reached from all parts of the islands." A superior advisory board, consisting of Messrs. Tomás G. del Rosario, Pedro Serrano Laktaw, Demetrio Larena, and Mena Crisologo, was intrusted with the task of locating the proper site for the school.

Nothing was to come out of the project for a few years, however. In 1903, Secretary of the Interior Dean C. Worcester wrote in his report that "much valuable time has been needlessly lost in establishing this college." A larger sum, ₱50,000, had been appropriated the previous year for buildings for the college, and "after long-continued delay, plans for a main building to contain laboratories, classrooms, offices and a dormitory for students were prepared" by the insular architect. A director of the experimental station was appointed on March 25, 1903, to take care of the Government property at La Granja and "begin the work of getting land under cultivation." However, no teachers were appointed and no college was established that year, "as it did not appear that teachers could be usefully employed prior to the erection of buildings in which they could teach and the gathering of students to be instructed by them." In 1904, La Granja was styled in the annual report of the chief of the bureau of agriculture as "agricultural college and experiment station," although, elsewhere in the same document, we learn that the "construction of the new building for the agricultural college at La Granja is in the hands of the insular architect, who, it is understood, will begin work at the close of the present rainy season."

Founding the present College of Agriculture

Three more rainy seasons had arrived and drawn to a close. But nothing was heard of any work begun on the new building. "Agricultural College" was, in fact, no longer mentioned in any bureau chief's report. It looked, indeed, as if the proposed agricultural college was destined to remain as a persistent, though elusive ideal.

In 1907, however, instead of a superior advisory board, a botany teacher in the Philippine Normal School was engaged to try his hand in starting the college. The teacher was Dr. E. B. Copeland. He had been, in addition to his other duties, also a botanist to the Philippine Government. His work had carried him to remote corners of the Archipelago. He knew the country well, and was, therefore, in a position to make an intelligently critical appraisal of prospective sites for an agricultural college. In addition to La Granja, in Occidental Negros, he considered three other places, all in Laguna province. The choice finally narrowed down to Los Baños. The reasons, in Doctor Copeland's own words, were: "For the school as a purely educational institution, the best site I have seen is Gagalit [a barrio of Majayjay, Laguna]; but it is a poor place for an insular experiment station, because of its exceptional coolness. For an experimental station, purely as a place of research, La Granja has the greatest natural advantages; but for a school, it is the least desirable place



EDWIN BINGHAM COPELAND
Dean, June 14, 1909, to August 30, 1917

under consideration, because it will surely attract the fewest students. Considering both demands on the site, I can without hesitation recommend that near Los Baños as the best, with Lake Calibato [in the barrio of Rizal, Nagcarlan, Laguna] as second." The sum of ₱100,000 was appropriated in that year for buildings and equipment, although, as in the case of earlier appropriations for similar purposes, there was no record that this money was ever expended.

At about that time, plans were on foot to create the University of the Philippines. The College of Agriculture, together with the School of Fine Arts, were to be the first two units of the new institution. During this preparatory period, the College temporarily had to be considered a school of agriculture under the Bureau of Education so that funds could be appropriated for it. The establishment of the College and, therefore, of the University, formally took place with the first meeting of the Board of Regents on March 6, 1909.

The College opened on June 14, 1909. There was no land that had previously been put under cultivation by an experiment station director, no blue prints of buildings for instruction and for dormitories from the draughting room of an insular architect, no misgivings about engaging teachers when they had neither classrooms to teach in nor prospective pupils to instruct. Doctor Copeland was the Dean. There were, besides him, three other teachers, whom he must have talked, in his convincing way, into joining him in a venture where angels for the eight years previous had feared to tread. Twelve students, from five Luzon provinces, including two from Manila, all of them former students of Doctor Copeland in the Philippine Normal School, enrolled on that opening day. There being no classrooms, they met mornings in the homes of their teachers. The farm of the new college consisted of about seventy-three hectares of wild land. The students had to hike every afternoon to the college farm for field work. It was a good four-kilometer stretch, over obscure foot trails.

Dean Copeland's faculty in those opening months consisted of Mr. and Mrs. Edgar Madison Ledyard,[2] who had previously been teachers in the Bureau of Education, and Mr. Harold Cuzner, from the Bureau of Agriculture. Mr. Ledyard taught zoölogy and entomology, and, in addition, acted as secretary, property officer, and what not; he was the Dean's right-hand man in the administration of the College. Mrs. Ledyard taught German, French, and also English, her position being instructor in modern languages. Mr. Cuzner, as farm superintendent, worked with his students in clearing the land of cogon and jungle growth; he also saw to it that the seed peanuts were planted in the soil, instead of supplementing the protein requirements of twelve growing young bodies. The teachers, more than anyone else, were fully conscious of their handicap in having to teach scientific Philippine agriculture at a time when scientific Philippine agriculture was practically non-existent. Through no fault of theirs, therefore, they usually barely managed to equip themselves for each class session one step ahead of their students. It is, indeed, to their credit that they, by dint of hard work, surmounted these handicaps, and were able to build up the first real tropical college of agriculture of university grade.

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[2] Mr. Ledyard died at Salt Lake City, Utah, on March 6, 1933.

CHARLES FULLER BAKER
Dean, September 27, 1917, to July 22, 1927

Soon attendance began to grow; toward the end of the year there was a student body of fifty-three. The faculty was reënforced by one additional member, Mr. Sam B. Durham, instructor in animal husbandry. Mr. Durham's excellent qualities as a field man are an old story. His dogged persistence in field work and his skill in manipulating farm implements, which he must have acquired in Oklahoma College, from which institution he had but recently graduated, marked him as an especially valuable asset during those formative days of the College of Agriculture.

Bienvenido Maria Gonzalez, '13
Dean, August 24, 1927, to the present

Because of the mounting number of students, soon classes could no longer be accommodated in the homes of faculty members. The problem of increased quarters was temporarily solved by setting up tents borrowed from the Bureau of Education, on the vacant lots at Camp Eldridge, which adjoined the town of Los Baños. Of all years, however, that particular one seemed to be the least propitious for camping. Nearly all the atmospheric depressions over the Pacific Ocean appeared to be bent on mischief for the special benefit of the new college community. Morning recitations and well-earned sleep at night were often rudely interrupted by collapsing tent roofs followed by a forced cold shower bath from the raging typhoon.

The construction of the "temporary building" on the College farm was a welcome move. It was completed in October, 1909, and was soon available for occupancy. Being the first building of the College, it housed classrooms, administration offices, tool shed, library, and was put to a host of other uses. After over a quarter of a century of active service, it remains to this day on the same spot on the banks of Molawin Creek, where it has always stood, each passing year investing it with added dignity and endearing it to the succeeding generations of faculty and students. It is no longer called "temporary building," but, more reverently, "Old College Building." Around it grew the College campus, with its twenty-two concrete buildings which house the classrooms and laboratories of the various departments of the College.

Photographic Division

OLD COLLEGE BUILDING
Built in 1909 as a "temporary building"; still in active service.

Student life in those pioneering days was perforce one of self-sufficiency. The students had to build their own houses, usually cook

Photographic Bureau

Palm Drive, College of Agriculture
The main road of the College

their own food with firewood that they themselves had to gather, and in short, manage to get along as best they could according to the fashion which Thoreau philosophized on in his *Walden*.

Two kinds of students were admitted: (1) intermediate graduates, who were assigned to the six-year course, the first two years of which were preparatory for collegiate work; and (2) high-school graduates, who took the four-year collegiate course. The six-year course led to the degree of bachelor of agriculture; the four-year course to the degree of bachelor of science in agriculture. This arrangement remained in force for twenty-two years, or until April 1, 1929, when the six-year course was discontinued, all the intermediate graduates that sought to enter being then taken care of by the newly established U. P. Rural High School.

The foundations laid by the organizers of the College have in a large measure stood the test of the twenty-seven years of life of the institution. One of the most unique features, the requirement of an undergraduate thesis, has consistently been adhered to and has proved its worth in insuring the quality of the students graduated. *The Philippine Agriculturist,* now completing its twenty-fifth volume, has been published almost uninterruptedly since 1911 and to-day represents in its over 13,000 pages one of the most complete and authoritative collections of scientific records bearing on tropical agriculture. The student body has from the first organized itself into a self-governing body, electing its own officers, and regulating student community affairs through duly appointed committees. Besides receiving valuable training in civic matters, the students thus considerably relieve the administration of the College from a number of routine duties.

Student material at the College

The College has drawn students from all the provinces of the Archipelago, as well as from eleven foreign countries and from the United States. The yearly enrollment has been as follows:

Year	*Total*
1909-10	53
1910-11	76
1911-12	137
1912-13	190
1913-14	239
1914-15	327
1915-16	382
1916-17	450
1917-18	564

Year	*Total*
1918-19	366
1919-20	462
1920-21	528
1921-22	622
1922-23	673
1923-24	648
1924-25	575
1925-26	606
1926-27	702
1927-28	789
1928-29	881
1929-30	781
1930-31	726
1931-32	641
1932-33	645
1933-34	527
1934-35	426
1935-36	436

A total of 4,759 students passed through the College of Agriculture from its foundation till the first semester, 1936. The range of geographical representation of the student body during the entire period till the close of the academic year 1935 was as follows. The geographical units are arranged in the order of the number of students that originated there.

Place of origin	*Number of students*	*Per cent*
1. Pangasinan	509	11.31
2. Laguna	495	11.00
3. Batangas	345	7.66
4. Occidental Negros	215	4.78
5. Rizal	202	4.49
6. Nueva Ecija	190	4.22
7. Iloilo	186	4.13
8. Bulacan	179	3.98
9. Cavite	174	3.87
10. Manila	157	3.49
11. Ilocos Norte	150	3.33
12. Pampanga	136	3.02
13. La Union	108	2.40
14. Capiz	106	2.36
15. Isabela	106	2.36
16. Tarlac	106	2.36
17. Tayabas	103	2.29
18. Ilocos Sur	98	2.18

Place of origin	*Number of students*	*Per cent*
19. Cagayan	90	2.00
20. Zambales	88	1.96
21. Albay	81	1.80
22. Cebu	79	1.76
23. Leyte	69	1.53
24. Bohol	61	1.36
25. Camarines Sur	54	1.20
26. Abra	40	0.89
27. Samar	37	0.82
28. Bataan	34	0.76
29. Antique	30	0.67
30. Nueva Vizcaya	27	0.60
31. Oriental Misamis	23	0.51
32. Sorsogon	20	0.44
33. Oriental Negros	17	0.38
34. Catanduanes	16	0.36
35. Occidental Misamis	16	0.36
36. Romblon	15	0.33
37. Davao	13	0.29
38. Cotabato	12	0.27
39. Zamboanga	12	0.27
40. Bukidnon	11	0.24
41. Marinduque	11	0.24
42. Mindoro	11	0.24
43. Mt. Province	11	0.24
44. Lanao	9	0.20
45. Masbate	9	0.20
46. Agusan	7	0.16
47. Palawan	7	0.16
48. Sulu	7	0.16
49. Surigao	6	0.13
50. Baguio	5	0.11
51. Camarines Norte	4	0.09
52. Batanes	2	0.04

In the foregoing tabulation, a total of 111 foreign students has not been included. These students constituted 2.41 per cent of the entire student body of the College. Their composition was as follows. With the exception of students who were recorded as from the United States, Spain, and possibly Japan, who happened to be temporarily residing in the Philippines for their own or their families' occupational reasons, all the foreign students came to Los Baños from their respective countries particularly to enter the College of Agriculture.

Place of origin	*Number of students*	*Per cent*
1. Siam	52	46.85
2. China	28	25.23
3. United States	12	10.81
4. Java	6	5.41
5. Japan	4	3.60
6. Hawaii	2	1.80
7. Sumatra	2	1.80
8. Borneo (Sarawak)	1	0.90
9. Guam	1	0.90
10. Portuguese India	1	0.90
11. Spain	1	0 90
12. Straits Settlements	1	0.90

The island-wide distribution of the student components of the College is a fair yardstick by which to measure the scope of its service to the country. Although only about 25 per cent of the students that entered this institution succeeded in graduating with a bachelor's degree, the rest had a chance to imbibe during their one or more years of student life a proportionate amount of the principles of scientific agriculture and, what is more, of the Los Baños spirit, to make them a wholesome influence in their respective communities.

Entrance examinations, such as those adopted and later on abandoned by other colleges of the University, have never been given to prospective students at the College of Agriculture. Applicants for admission were taken in as they came whenever existing facilities permitted, provided they fulfilled the standard requirements in educational preparation, passed the medical and physical examinations conducted by the College physician, and paid the necessary fees. The quality of the students, however, is determined by the culling process. During the first eight years of the College, Botany 1, which was given in the first year preparatory course, served as the sieve, "letting," according to Doctor Copeland, "only the finer material through." Later, selection was made more rigorous by having the Secretary of the College issue "delinquency reports" three times during the academic year. The bright but indifferent students, the dull and lazy, and at times the dull though diligent sooner or later find their names gracing the Secretary's rolls. In this manner, a fairer appraisal obtains, because based on a more intimate knowledge of the individual students' adaptability for a technical agricultural course. The burden of weeding out the unpromising

A. P. Varona photo

A LABORATORY BUILDING, COLLEGE OF AGRICULTURE student material obviously largely falls on the shoulders of the faculty that teach the first-year and, to some extent, the second-year subjects. On account of the frequency in the issuance of the delinquency reports and the rigid application of delinquency rules, casualty due to poor scholarship grows less and less with each upper class.

The students that succeed in justifying their continuance in the College have to keep on proving their worth. The standards maintained may be surmised from the fact that a computation of the performance of students during eleven years, from 1921 to 1932, showed that out of every group entering the College as freshmen, an average of only 56.60 per cent became seniors upon reaching the fourth year. A large proportion of the rest had been eliminated during the four-year period of rigorous selection, while a relatively small minority had been unable to meet the requirements on time and did not become seniors until later. Likewise, out of every senior class, an average of only 56.41 per cent could come up with their caps and gowns during the year when they were expected to graduate.

A. P. Varona photo

HARVEST TIME AT THE AGRICULTURAL EXPERIMENT STATION

Special ability and industry which mark individuals as particularly outstanding among their fellows are given encouragement through suitable tokens of recognition. The most common form of reward for meritorious students is appointment as student laborers, student janitors, and student assistants. The salaries for these positions are not much, since they range from only ten to sixteen pesos a month; but they are sufficient to enable the recipients to at least partly work their way through college. In the early days of the College, nearly all the undergraduates could get a job of some kind. At present, however, only approximately 14 per cent of the student population of the College gets a chance in this way to secure some kind of financial aid and in addition acquire greater skill along various lines of agricultural work. Not the least of the beneficial effects of this arrangement is the development of the proper attitude among young people, who early in their career experience the thrill of earning a living. Putting such students on the payroll is by no means a mere philanthropic gesture on the part of the College, because trained and educated helpers such as these are an invaluable aid in carrying out the numerous exacting projects of the different technical departments.

Two scholarships are available: (1) the Baker Memorial Scholarship and (2) the Baylon-De La Rama Scholarship. Both of these scholarships began operating in 1930. The first, established by contribution from the students, faculty and employees of the College and from other friends of the late Dean C. F. Baker, carries a small sum of money which is awarded to a self-supporting senior with good grades, good moral character, and promise of future usefulness, the idea being to relieve him of financial worries during his concluding months at the College. Ten students have so far been awarded this scholarship, as follows:

1930. Ambrosio V. San Pedro
1931. Engracio Basio
1932. Juan S. Padilla and Marcelino Canlas
1933. Filomeno Butac and Proceso E. Alcala
1934. Maxima Mulimbayan
1935. Fernando Torres
1936. Flaviano P. Olivares and Felix N. Salcedo

The Baylon-De la Rama Scholarship is available only to students who pursue the course in sugar technology. It is awarded through competitive examination, and the winning candidate is supported through college at the expense of the fund. So far six students, Julian Gomeri, Manuel R. Monsalud, F. de Leon Flores, Abelardo

Bantug, Trinidad Q. Alconcel, and José K. Demeterio have held this scholarship, from 1930 to 1936.

There are other forms of recognition, although they carry no monetary award. The distinction of being graduated with honors is coveted by many but obtained by a very few. Since the foundation of the College, only twenty-four students, or about 2 per cent of all the graduates, were able to realize this ambition. Graduation with the highest honors is temptingly provided for in the catalogue, but has never been granted so far. Almost equally difficult of attainment are the special prizes and medals, which have been obtained by a select few, as follows:

1. Faculty Medal of Merit, award of which is "based on scholarship, accomplishment in athletics, qualities of leadership, moral character, manliness, and promise of good citizenship"; awarded to Gonzalo H. Salazar in 1925 and to Salvador B. Oliveros in 1933.

2. The Class of 1925 Medal, for the best undergraduate thesis presented: awarded to Toribio Mercado (agronomy) in 1926, to Pedro S. Paje (poultry husbandry) in 1927, and to Catalino T. Buligan (entomology) in 1928. The funds provided for this purpose ran out in 1928.

3. The Atherton Lee Prize, also for the best undergraduate thesis presented: awarded to Getulio B. Viado (entomology) in 1933. The funds for this prize were offered for one year only.

4. The Joaquin J. Gonzalez Medal, for "the graduating student who has the highest academic average for his entire course": awarded to Paul Sindhuravejña (from Siam) in 1925, to Benjamin L. Hollero in 1927, to Genaro C. Bermejo in 1929, to Ricardo T. Marfori and Manuel Villano in 1930, to Julian Gomeri in 1931, to Trinidad Villas in 1932, to Salvador B. Oliveros in 1933, and to Felix de Leon Flores in 1935.

Co-eds

The idea prevailed for a long time that the College of Agriculture was an institution where the nature of the work was fitted only for young men. It was not until the College was twelve years old, in 1921, that one young lady summed up enough courage to try her luck in pursuing an agricultural course side by side with 621 male students. She disappeared from the campus at the end of one summer. In 1922 another co-ed enrolled; and in 1923 there were two of them. The number has gradually increased since then. A total of

66 young women (including 4 Chinese) have attended the College of Agriculture during the past sixteen years, nine of whom, or 13.48 per cent, are now holders of bachelor's degrees.

That young women can hold their own even in a reputedly young men's college is shown by the fact that the highest position within the gift of the student body, that of its president, was held by Miss Mamerta Manahan in 1926. No mere display of gallantry, this. Just as big brother usually snubs his little sister, man through the ages has not yielded without resistance his prerogative as the stronger sex. Likewise, in 1927, another co-ed, Miss Victoria B. Mendiola was secretary of the student body; and from year to year one fair member or another has graced no less important positions, such as membership in the student council or in student-body committees, or marked distinction in scholarship.

J. B. Banzon photo

CAMPUS BRIDGE, COLLEGE OF AGRICULTURE

Loyalty Day

October 10 of each year is a special red-letter day for the College of Agriculture. The Board of Regents, acting upon a resolution of the Student Body on January 10, 1922, declared this date Loyalty Day. Classes and other activities are suspended in order to celebrate the event that took place on October 10, 1918, when the faculty and students of the College volunteered as a body in the Philippine National Guard.

Courses at the College

For twelve years after the foundation of the College, the curriculum remained basically unchanged, except in 1917, when the two years of German were eliminated in order to give way to agricultural economics, farm practice, blacksmithing, and carpentry. During that year, likewise, plant pathology was made an elective one-year course with entomology; subsequently, however, both subjects were made required semester courses. Military preparedness was provided for in 1916, when enrollment in military science became obligatory to students.

The Animal Husbandry Curriculum, for either intermediate or high-school graduates that wanted to take specialized work in animal husbandry, was established in 1921. So also was the Sugar Technology Curriculum, which, however, was available to high-school graduates only. A combined Animal Husbandry-Veterinary Science Curriculum, to which only high-school graduates were admitted, began operating in 1925.

In 1929, after the six-year course for intermediate graduates had been abolished, the general curriculum of the College was reorganized. As explained by Dean Gonzalez, the "new curriculum was drawn which aims to give the student during the first two and a half years of his course a broad basic training in the sciences fundamental to agriculture, as well as in agricultural subjects of general application. The last year and a half is devoted almost entirely to training along specialized agricultural subjects elected by the student." This revised curriculum is still in force. However, on October 12, 1936, the faculty of the College adopted a new revised curriculum, and this was recently approved by the University authorities. This new revision, which is to become effective in June, 1937, leaves the time-tested basic plan of instruction of the College practically intact; but eases off the students' exceptionally heavy academic load by a total of ten units. Likewise, the summer practical farm experiences are being abolished. Drastic reduction in units has taken place especially in the prescribed and major electives. A new course, that on rural sociology, is being introduced in the new curriculum.

A two-year curriculum, leading to the title (not degree) of associate in agriculture, has also been approved. The first year of this new curriculum will be identical with that of the degree course. In the second year, practical subjects, largely in agronomy and animal husbandry, are prescribed. The brief course is intended for those students who are not inclined to go through the more arduous disciplines of a regular four-year degree course but who may desire to acquire some of the rudiments of technical agriculture in order to fit them for farming.

A. P. Varona photo

A Corner in the Animal Husbandry Compound

More detailed announcements of the new revised degree course and of the short course will be given in the next issue of *The Philippine Agriculturist.*

Undergraduate thesis

When the student reaches his junior year, he elects the department in which he expects to major. A professor in the department is assigned as his adviser, who helps him select his prescribed electives and plans with him the subject and scope of his thesis. The thesis represents one year, but more often two years, of intensive work along some agricultural problems, wherein the student gets a thorough training in carrying an independent investigation, and in collecting, arranging, correlating, and interpreting data. Under the guidance of his adviser, he is taken in as raw, inexperienced material, and patiently piloted through the exacting disciplines of scientific research. The resulting theses in many cases have been of high quality, comparing favorably with the average run of masters' theses elsewhere.

In the earlier years of the College nearly all the students were obliged to major in agronomy, inasmuch as this was then the only department that had the necessary facilities. Later, as the other departments became better prepared, they also drew thesis students, although naturally not to the extent equal to that of agronomy. The following table gives the total distribution of thesis students in the different departments from March, 1911, to March, 1936:

Department	*Number*	*Per cent*
Agronomy	507	46.60
Agricultural Chemistry (10.29%)	112	16.36
Sugar Technology (6.07%)	66	
Animal Husbandry	165	15.17
Agricultural Botany (Plant Physiology)	63	5.79
Soils	43	3.95
Plant Pathology	38	3.49
Agricultural Engineering	33	3.03
Entomology (including Zoölogy)	30	2.76
Agricultural Economics	29	2.67
Forestry	2	0.18
	1,088	100.00

The inclusion of two students who presented bachelor's theses in forestry needs some explanation. The Forest School was originally established on June 12, 1910, as a department of the College of Agriculture. This arrangement obtained for six years, until April 1, 1916, when it was created as an independent school of the University. It was during this period, when the College was foster-mother to that School, that the two degrees in forestry were granted, in 1915.

Likewise, the combined Animal Husbandry-Veterinary Science Curriculum was a sequel to the transfer of the College of Veterinary Science to Los Baños on July 7, 1919. This curriculum, of course, was automatically abolished with the action of the Board of Regents at its meeting of March 17, 1933, returning the College of Veterinary Science to Manila.

A. P. Varona photo

A SECTION OF THE ORNAMENTAL NURSERY

Master's degree

Postgraduate study in the College of Agriculture is under the general supervision of the University Graduate Committee, in which the College has at present two representatives. A master's degree in agriculture was first granted in 1913. After a lapse of three years, another was granted in 1916; and every year thereafter, up to 1925, a limited number of candidates came up for the degree. In 1925, the postgraduate courses had to be suspended at the College. The situation was brought about, as summed up by Dean Baker in his annual report for that year, by "the cumulative effect of gradual loss from the staff of men of higher grade who are actually capable of carying proper postgraduate work. We built up here what amounted to a fully developed graduate school and for a short time it was a most successfully efficient one. Large numbers of men were crowding forward to take advantage of the great opportunities presented by it and the number of candidates for the master's degree presented by this College was rapidly increasing. However, the rapid dilution of our most effective personnel made it impossible to continue to carry the postgraduate curriculum without seriously jeopardizing the success of the basic work of the College. Therefore, it had to be discontinued to the great loss, I believe, of the University and the Filipino people." Since that year, activity in graduate work at the College has been spasmodic, there having been only one additional master's degree granted, in 1932. There is to date a total of only thirty-six holders of master's degrees from the College of Agriculture.

Research facilities

The campus and experimental farms of the College comprise an area of 397 hectares of diversified land. The greatest portion of the farm was acquired through Act No. 2730 of the Philippine Legislature on February 15, 1918, appropriating the sum of ₱125,000 for the establishment of the Experiment Station at the College of Agriculture. Large numbers of cultures are maintained in addition to permanent plantings which consist of about 25,000 trees and shrubs. Domestic animals of different breeds are kept, largely for experimental work. The Maquiling area, which the campus adjoins, has been a forest reserve since 1910. By proclamation of the Governor General, it was converted into a National Park in March, 1933. It embraces 3,787.5 hectares of rich natural vegetation that teem with wild forms of animal life. Since 1929, the College has been operating a limnological station at Mayondon, on the shore of Laguna de Bay. The ten technical departments of the College have from the beginning strived to equip themselves with most of the essential apparatus and other necessary adjuncts to research. The College

Library is fairly well equipped with references on agricultural topics; it has on its stocks a collection of 14,954 volumes, 2,994 pamphlets, 849 manuscripts (theses), and an assortment of maps. Its periodical resources consist of 121 paid subscriptions, 266 exchanges, in journals and other serial publications mostly on agricultural and scientific subjects.[3]

The faculty

With the foundation of the College, the question of building up an adequate staff of duly qualified teaching personnel presented considerable difficulty. The College was particularly fortunate in the past to be able to engage the services of Americans and Europeans who had had tropical experience for teaching technical agricultural subjects. Distance from home, however, and the enervating effect of tropical climate on people from colder countries usually worked to shorten their tenure of office in the Philippines. There has been a succession of sixty American and two European teachers in the history of the College. Their average length of service was about 4 years. Only three of them, and these are relatively recent arrivals, still remain at their posts.

As was foreseen by Dean Copeland himself, as well as by his successor, Dean Baker, the only permanent solution was for the College gradually to build up the faculty from its own graduates. There has been a total of 69 of these local products that from time to time were taken into the faculty ranks. Their average length of service has been about 10 years. Most of them are still in the service. Those few that left the College are nearly all working elsewhere in the Philippines, so that they continue to be useful to the country. In the present composition of the faculty, the dean and all the heads of departments are Filipinos, all of them graduates of the College of Agriculture. So is the personnel of all the technical departments. Of the total of 54 faculty members (instructors and above), only three are Americans (in the Departments of English and Agricultural Education), the rest being Filipinos, who are nearly all alumni of this College. The training of most of these ranking Filipino members of the faculty was supplemented by postgraduate education in their respective lines abroad, in various universities where they were sent as fellows or pensionados of the Philippine government. They, therefore, had the dual advantage of earlier apprenticeship under their former professors at the College and, later, of more specialized instruction in foreign institutions. Following is a list of the overseas institutions where these Filipino members of the faculty took postgraduate courses and the number that attended each.

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[3] Figures furnished by Mr. Quintin A. Eala, librarian, College of Agriculture, December 4, 1936.

Institution	*Attendance*
1. Cornell	8
2. Iowa	4
3. Wisconsin	4
4. Illinois	3
5. Chicago	2
6. Harvard	2
7. Johns Hopkins	2
8. Minnesota	2
9. Nebraska	1
10. Stanford	1
11. California	1
12. Columbia	1
13. Massachusetts Institute of Technology	1
14. Princeton	1
15. Texas	1
16. Yale	1
17. Göttingen (Germany)	1
Total	36

Pertinent to this topic are the following remarks quoted from Dean Baker's writings: "One of the more serious special undertakings of the College has been the gradual building up of a highly trained Filipino faculty itself. For this purpose, as well as for the training of the future technical men needed in this country in the agricultural sciences, men showing special ability and special aptitudes in the various directions are selected from among hundreds while still in undergraduate work. Such men are then given constant grooming until ready to go abroad for higher training. This system has produced uniformly satisfactory results, all such men having, as a rule, succeeded abroad, and in their work here thereafter."

Needless to say, these arguments are not advanced to raise any question regarding advisability of further employing Americans and Europeans on the faculty of the College of Agriculture; but merely to show the practical difficulties in depending on imported supply to replenish the faculty ranks, especially at the prevailing low scale of salaries. It is admitted as patent that the infusion of desirable foreign blood into the faculty is conducive to a healthier development in any institution. Recognition of this truth in part actuated the present Filipino dean, Dr. B. M. Gonzalez, to take vigorous steps toward the establishment of the Baker Memorial Professorship, which would enable the College to attract a succession of renowned foreign workers to the faculty. In 1930-1931, the chair was occupied by the late Dr. Frank Lincoln Stevens, then professor of plant pathology, University of Illinois. Unfortunately, the position had to be abolished on account of the depression.

Record of graduates

About 85 per cent of those who graduated have taken up occupations that are agricultural in nature. The remainder that pursued other lines of work certainly can use their well-rounded technical training in numerous phases of their new careers and thus make of themselves better physicians, merchants, etc.

In the Government service, the faculty of the College of Agriculture, where the dean and almost the entire teaching staff are alumni, has been pointed out above. The director and a large majority of the staff, including a number of division chiefs, in the Bureau of Plant Industry are likewise alumni of this College. Products of this College are also holding responsible positions in the Bureau of Education, especially as principals or as teachers in agricultural schools, and in the Bureau of Science. The extensive agricultural projects of the Bureau of Prisons, the Philippine Army, and other branches of the Philippine government, as well as governments in some of the neighboring countries, have utilized the services of our alumni.

There is hardly a sugar central in the Philippines where College of Agriculture graduates are not found, a good number of them occupying places of trust and responsibility.

There are, likewise, graduates who went into "dirt farming" and have been eminently successful. The College has always been quick to give due recognition of such meritorious achievements. One alumnus, Mr. José F. Zamora, B.Agr., '11, was granted in 1917 the honorary title of Master Farmer, and a similar distinction was accorded in 1923 to Mr. Gregorio Francisco, B.S.Agr., '17, and Mr. Florentino Cruz, B.Agr., '16, the first two for outstanding success in farming and the last, in cattle ranching.

Other alumni, too numerous to mention, have made their mark in different branches of natural science, not a few of them being honored by memberships and fellowships in exclusive local and foreign scientific societies.

Contributions of the College to the country

The discussion has so far dwelt mainly on only one of the functions of the College of Agriculture, namely, instruction. A second function, research, has from the beginning been considered paramount in the activities of the institution. Largely through the requirement of undergraduate theses, but also through the independent efforts of the faculty, investigational work along different lines of agricultural science has been pushed in the College of Agriculture to a degree that is perhaps unparalleled in any other similar research institution in the Philippines. To date there has been a total of about 1,200 scientific papers and over 500 popular and semipopular articles published by the faculty and students. Research projects are constantly under way in the different departments.

The quality of the scientific papers is reasonably assured by the practice of subjecting them to unsparing criticisms of colleagues prior to publication. The Los Baños Biological Club, which was organized on November 15, 1923, has held monthly scientific meetings during the school year since December 4, 1923. Papers based on local research receive in these meetings the benefit of being dissected and improved through constructive suggestions of other investigators. Another organization, the honorary Society for the Advancement of Research, established on September 11, 1928, along the same plan as the Sigma Xi society in the United States, whose charter members are affiliated with the various American chapters of the latter society, has its headquarters at Los Baños.

Of the so-called practical contributions, various achievements, among others, may be cited as results of the research activities of the College. These are the creation of breeds of domestic animals, like the Berkjala pig and the Los Baños Cantonese chicken, which have gained their way into popular appreciation as superior breeds that are well adapted to Philippine conditions; scientific feeding and new useful food stuffs for man and domestic animals; operation of silos, the two on the College Campus having been for eight years, from 1928 until very recently, the only working models in the whole Archipelago; industrial utilization of animal and plant products, which includes the finding of a rational method of commercial ham-making without the aid of refrigeration in the Philippines; the discovery of the causal organism of the coconut budrot and the modes of transmission of the bunchy-top of abacá and of the Fiji disease of sugar cane, that point the way to more satisfactory methods of control of these destructive diseases of important money crops; extensive plant introduction and acclimatization tests; selection and distribution of seeds of Philippine crops; bionomics and methods of control of insect pests; prediction of trends of locust outbreaks; methods of conservation and protection of freshwater fisheries; tests of alcohol mixtures as fuel for internal-combustion engines; fertilizer requirements of rice and other crops; and scores of others. The fact should not be lost sight of, however, that progress in any branch of human endeavor, although at times markedly accelerated, is not built up by spectacular achievements alone, but rather, largely, through an accretion of a multitude of little findings. The College in its twenty-seven years of existence, has produced through its different technical departments, a mass of scientific results that have been drawn upon, not only to form the basis of proper instruction in Philippine agriculture, as has been its avowed purpose, but also directly to aid the farmer.

Support of the College

The following table is presented without discussion:

Relative shares in annual appropriation for maintenance of the College of Agriculture and the entire University, 1916-1936

YEAR	U. P. TOTAL	COLLEGE OF AGRICULTURE ALLOTMENT	PROPORTION TO U. P. TOTAL
	pesos	*pesos*	*per cent*
1916	725,000	146,785	20.25
1917	739,200	153,540	20.77
1918	739,200	205,540	27.81
1919	1,370,720	318,820	23.26
1920	1,330,000	402,880	30.29
1921	1,450,000	389,290	26.85
1922	1,450,000	339,304	23.40
1923	1,573,000	336,657	21.40
1924	1,573,000	360,274	22.90
1925	1,580,000	381,186	24.13
1926	1,800,000	377,310	20.96
1927	1,800,000	373,660	20.76
1928	1,836,000	347,382	18.92
1929	1,836,000	371,700	20.25

YEAR	U. P. TOTAL	COLLEGE OF AGRICULTURE ALLOTMENT	PROPORTION TO U. P. TOTAL
	pesos	*pesos*	*per cent*
1930	2,082,015	402,740	19.34
1931	2,172,607	402,720	18.54
1932	2,017,045	377,220	18.70
1933	1,472,651	297,621	20.21
1934	1,309,917	268,965	20.53
1935	1,208,861	246,852	20.42
1936	1,237,716	249,176	20.13

Figures from 1916 to 1929 for U. P. total are from General Appropriations by Insular Government.

Figures from 1930 to 1936 are from U. P. budgets.

The Department of Agricultural Education was organized in 1928 and allotted an initial separate appropriation of ₱25,000.00 for maintenance that year and a similar amount in 1929. Beginning 1930 its support is included in the general U. P. and College figures.

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EMBRYOS OF CARABAO MANGO (MANGIFERA INDICA LINN.)[1]

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Of the Department of Agricultural Botany

WITH TWO PLATES

Much interest has been shown on the behavior of the embryo in some of the mango varieties now grown in the Philippines (Juliano, 1934; Juliano and Cuevas, 1932), because of the possibility of improving them by hybridization. Among our native mango varieties, the carabao stands supreme as to size and flavor. Whether or not this variety can still be improved is yet to be known. This improvement would greatly depend upon certain fundamental facts and on the whims and desires of the breeder. Thus, a knowledge of the behavior of its zygote after fertilization might be of great help to any prospective hybridizer of this important fruit-producing plant.

One thing worthy of note in connection with the different mango varieties now found growing in the Islands, is the fact that we often observe the development of more than one sprout from its seeds, the only exception being perhaps the Cabayo and the Dudul varieties, which were not mentioned to be polyembryonic by Wester (1920). Since the study of the embryology of our pico mango (Juliano and Cuevas, 1932) and of the "strawberry" mango seedling from Hawaii (Juliano, 1934) has been conducted, many points of interest to the breeders have come to light. Whether or not the zygote of the carabao mango behaves like that of the pico or the "strawberry" mango, available literature does not seem to show. For this reason, this brief report, which attempts to present some findings along this line of inquiry, might be of interest to the practical breeder of the mango.

On April 18, 1933, the writer in company with Mr. Felix B. Sarao, of the Department of Animal Husbandry, collected material from old carabao mango trees growing in the latter's yard in Barrio Medicion, Imus, Cavite. Some of the trees were then already in fruit, while others were still flowering very profusely. From these different trees young as well as mature hermaphrodite flowers and young fruits in different stages of development were gathered and pickled in formalin-acetic-alcohol (70 per cent) prepared according to the formula given by Chamberlain (1932). The material was then taken to the Agricultural Botany Laboratory that same day, and on the day following all the individual pistils with their corresponding megasporanges were taken and fixed in fresh formalin-acetic-alcohol, after removing slabs from their two sides. In the case of the fruits, the seeds were removed and these were fixed and killed with the same fixative. The material was treated in the usual way and embedded in paraffin. Sections 8 to 10 microns thick were cut, and these sections were stained in Heidenhain's iron-alum haematoxylin with aniline orange gold dissolved in clove oil as a counterstain.

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[1] Experiment Station contribution No. 1157.

OBSERVATION

No attempt was made to trace in detail the development of the megagametophyte in the carabao mango. The material, however, clearly indicates that it follows that which had been reported for the pico mango (Juliano and Cuevas, 1932).

At anthesis, the megasporange possesses an embryo sac with an egg apparatus fully differentiated and the fusion nucleus is either at the vicinity of the egg apparatus (Pl. 1, fig. 7) or away from it at one side of the sac (Pl. 1, fig. 5). The synergids are somewhat pyriform to nearly oblong or trapezoidal, the cytoplasm of which is thickest at their micropylar ends wherein their oblong to nearly rounded nuclei are embedded. At the center of each of the synergids is a large vacuole. The megagamete is usually found between the pair of synergids, and is usually larger than the latter. Its nucleus is large, usually oblong, and possesses a large nucleolus and dense nucleoplasm. The egg apparatus is indeed very similar to that found in pico mango (Juliano and Cuevas, 1932). At this time the antipodals are absent, a feature very much identical to that obtaining in our pico mango and also in "strawberry" mango (Juliano, 1934).

The synergids are rather persistent. They usually persist for a while after fertilization (Pl. 1, fig. 3 and 4), and degenerate only when enlargement of the embryo sac has commenced and when the zygote begins to show signs of activity (Pl. 1, fig. 6). In some cases, however, signs of degeneration of the synergids may be seen even before fertilization and after anthesis (Pl. 1, fig. 5). Degeneration of the synergids is not uniform; one of them may degenerate ahead of the other, or both may degenerate simultaneously (Pl. 1, fig. 5 and 6).

Zygote. The zygote does not divide soon after fertilization (Pl. 1, fig. 2 to 4, and 6), but may remain dormant even after endosperm formation is underway (Pl. 1, fig. 9). The synergids, however, may persist for a while. Concominant with the disintegration of the synergids, the embryo sac commences to enlarge and elongate rapidly, with its enlarged portion usually directed towards the micropyle, but chalazal enlargement is not rare among the sections examined by the writer. The nucellar cells surrounding the embryo sac become densely filled with cytoplasm, especially at the micropylar end, before they finally degenerate. The lateral as well as chalazal nucellar tissues are the first to succumb to the enlarging embryo sac; while the micropylar and those contiguous to the funiculus are the last to disappear (Pl. 2, fig. 11).

While early divisions of the zygote have not been studied by the writer in detail, his slides clearly show that the zygote actually forms an embryo. In some cases, however, the zygote exhibits signs of degeneration (Pl. 1, fig. 8), so that whatever embryos are formed in the seed, they come from the nucellar tissue near the micropylar end of the sac (Pl. 1, fig. 12). It was the experience of the writer during his examinations of his numerous slides that for every hundred perfectly looking young fruits with correspondingly well developed young seeds, about half of them exhibited signs of degeneration in their zygotes similar to figure 8 of plate 1, while the remaining half possessed seemingly functional zygotes.

It may thus seem fairly safe to state that from among well developed seeds of carabao mango, only half of them possess sexually as well as asexually produced embryos (if polyembryonic); the remaining half are devoid of sexual embryos and instead only asexually produced ones are formed. If only one sprout arises from a seed on germination, this seedling may have been produced either asexually or sexually as one of the embryos has all the chance to outgrow the other in the sac. In fact, the struggle for development among the growing embryos in a seed is so great that the unfit are eliminated and become either aborted or degenerated. Few embryos which may struggle on in the seed often give rise to weakling sprouts at germination.

As to how to distinguish macroscopically a mature carabao seed possessing only asexually produced embryos from those which have both the sexual and asexual embryos, the writer has as yet no data to present. In Citrus (Frost, 1926), however, experimental evidence seems to indicate that varieties differ greatly in the relative abundance of apogamic embryos, and that, in varieties which produce relatively numerous adventive embryos, the sexual embryo is relatively crowded out. Negative correlation between vigor of apogamic embryos and the percentage of viable sexually produced progeny has been obtained in Citrus. Varieties which produce relatively few adventive embryos can be more economically used as seed parent. This situation may find its parallel in the mangoes.

A similar behavior of the zygote reported for carabao mango has been noted in pico (Juliano and Cuevas, 1932). In the latter variety, however, there is more preponderance of seeds with sexual embryos. Also the writer observed more embryo sin the sac of pico (Juliano and Cuevas, 1932) than in carabao (Pl. 2, fig. 15). Consequently, it would perhaps be much better to use carabao as parent seed in hybridization work, as a breeder will have to deal with less embryos in a seed.

In "strawberry" mango the zygote totally fails to develop (Juliano, 1934), and all the embryos in a seed are apogamic. It becomes, therefore, quite evident that the female parent of this variety is not suitable for use in hybridization work. In this connection, the writer is of the opinion that perhaps the pico and carabao mangoes are both on their way to sterilization and degeneration in their zygotes so that time may come when one would be able to grow these two varieties by seedage, the progenies of which will come true to type, a condition now obtaining in the "strawberry" mango (Juliano, 1934) and the Florida No. 11 mango (Belling, 1901).

Endosperm. Material available to the writer shows that the primary endosperm nucleus does not divide soon after fertilization, but usually develops ahead of the zygote. Free nuclear divisions take place as in pico mango (Juliano and Cuevas, 1932), and the free nuclei take peripheral positions (Pl. 1, fig. 9-10; Pl. 2, fig. 16). Wall formation becomes discernible first at the micropylar region of the sac (Pl. 2, fig. 12), proceeding towards the chalaza. However, the cellular endosperm does not persist, and is totally absorbed by the embryos as fast as they are formed.

Adventive embryos. As stated above, the embryo sac destroys the nucellar tissue much more rapidly on the lateral as well as chalazal region of the megasporange. In carabao mango, the development of the adventive embryos is discernible only after the zygote has distinctly formed the sexual embryo (Pl. 2, fig. 11-12). As destruction of the nucellar cells at the micropylar region of the sac progresses, the embryo sac directly comes in contact with the epidermal cells of the nucellus opposite the funiculus. Some of these epidermal cells actually become active and exhibit either enlargement or periclinal divisions of their nuclei (Pl. 2, fig. 12) or both. These epidermal cells of the micropylar nucellus are responsible for the formation of adventive embryos. In pico and "strawberry" mango, this activity of forming asexual or adventive (apogamic) embryos are delegated to some of the nucellar hypodermal cells near the micropylar end of the sac. In carabao mango, these hypodermal nucellar cells may perhaps develop adventive embryos, but the writer was not able to detect any one instance where the adventive embryos are actually formed from them. Neither did he find any of these hypodermal nucellar cells exhibiting any sign of activity, except in one instance. This is shown by a characteristic swelling with distinct vacuolation and nuclear enlargement, but those are all that those cells actually do (Pl. 1, fig. 10). It seems that if these cells actually do form embryos, it must be a very rare case.

In Citrus, it seems that the presence of sexual embryo is a necessary stimulus to the development of apogamic embryos (Frost, 1926), but in carabao mango, as well as in pico (Juliano and Cuevas, 1932) and the "strawberry" mango (Juliano, 1934), it is not always the case, although fertilization is essential for the complete development of the seed (Juliano and Cuevas, 1932).

The behavior of the embryos in the carabao mango, as well as in the pico mango, perhaps affords a form of "development selection" (Buchholz, 1922). The embryo from the fertilized megagamete must compete for food and space with the apogamic embryos in the same seed. In mango, Citrus and other angiosperms, this embryonic selection must necessarily come up so close together that a keen competition between them will inevitably come during their development in the young seed as well as during germination.

The sexual embryo may grow and develop ahead of the asexual embryos (Pl. 2, fig. 14 and 15) and at maturity it is the largest of all the sprouts in the seed. This is not always the rule, however, as cases where the asexual ones are larger than the sexual (Pl. 2, fig. 13 and 16), are present. Where two or more embryos which are nearly identical in size are found in an embryo sac, the difficulty of distinguishing the sexual from the asexual embryos increases, and only their relative positions can be used as a criterion by which one can differentiate one from the other. For instance, the one nearer the micropylar end is in all probability the sexual embryo while those farther away are the asexual ones (Pl. 2, fig. 13 and 16). This may only be true when the embryos are small, but at an advance stage (Pl. 2, fig. 15) the situation is reversed. Where the sexual embryo has developed very much ahead of the asexual ones, differentiation between the two becomes less difficult microscopically.

The asexual embryos have all the chance of crowding out the sexual embryo which degenerates early (Pl. 1, fig. 8), or the asexual embryos may actually develop much faster than the sexual (Pl. 2, fig. 13, 14, and 16). All these conditions are apt to happen in the developing seed of carabao mango, as well as in other mango varieties which are polyembryonic. It is, therefore, unsafe to use vigor as a guide in deciding which among the sprouts is the sexual. In fact, in Citrus the nucellar buds which reproduce the variety without change, are observed to increase in vegetative vigor, and according to Robinson (1933) this rejuvenescence in citrus varieties made possible through nucellar bud propagation has been pointed out by Swingle in 1932 and was given the name, "neophysis." It would perhaps be possible that some other methods could be found by which the sexual embryo could be differentiated from the asexual sprouts coming from a single seed, but in so far as the writer has been able to find, it is rather difficult to determine with any degree of certainty at present the adventive embryos from the hybrid embryo.

The practice of carabao mango growers in Cavite[2] is to allow only the most vigorous sprout from among those that come out from a single seed to live. Experience shows that sometimes mango growers obtain from these "vigorous" seedlings a form of mango, which is not at all carabao. It may, therefore, be surmised and suspected that they obtain the sexually produced embryo to grow. In the majority of cases, however, they get the carabao type from those vigorous sprouts. It is apparent, therefore, that vigor of the sprout is not the safest criterion to use in distinguishing the sexual from the asexual, and vice versa, although indications are that the asexual embryos often gain ascendancy over the sexual during the development of the seed.

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[2] Thanks are given to Mr. Alejandro Sarao, of Imus, Cavite, for the valuable information.

In pico mango, the distinction of the sexual from the asexual embryos during germination is more difficult. Even at the early stage of their development, the sexual and the asexual (apogamic) embryos develop at nearly the same time and at about the same rate. The production of more sprouts in pico mango seeds during germination adds to the difficulty of selection.

In a personal communication to the writer by Mr. A. P. C. Bijhouwer, mango investigator to the Government, Pasoeroean, Java, it is revealed that of the 39 forms of Javan mango (*Mangifera indica* Linn.) not one was found to be monoembryonic, as shown by the large number of sprouts. Mr. Bijhouwer reports that *Mangifera odorata* (huani) is polyembryonic; *M. foetida* (batjang), monoembryonic; alphonso, monoembryonic; and Saigon (Cambodiana), polyembryonic. Rolfe (1915) observes that polyembryony is only true in Cambodiana, No. 11 Florida mango, and the Bombay in Florida. Amini produced many fruits without seeds in 1914 in Florida; a few fruits, however, contained seeds with one embryo each, and two seeds appeared to be polyembryonic. Moreover, Wester (1920) quotes that in India where there are probably five hundred mango varieties, there is no known polyembryonic mango. Of the many Indian mangoes (Wester, 1924) cultivated and fruiting in the Lamao Horticultural Station of the Bureau of Plant Industry, some produce monoembryonic seeds, while others produce both mono- and polyembryonic seeds.[3] Among the varieties said to be producing monoembryonic seeds are Naspati, Sandurea, Bombay Yellow, Langra, Kutna and Surkha. The varieties that are reported producing polyembryonic seeds are Amini, Skrikhas, Catchamita (Katchamita), Cambodiana, and Suffaida. The Catchamita was found to produce 13 polyembryonic seeds and 18 monoembryonic seeds out of the 31 seeds germinated in 1935. This behavior of these Indian mangoes in the Islands, which is outside of their country of origin, is indeed very interesting.

With the exception of Mulgoba (Wester, 1920), which has reverted to polyembryony in its first generation when grown in Florida, very few actually revert to polyembryony outside of India. In the Philippines, and in Lamao, province of Bataan particularly, the monoembryonic mangoes of India (Amini, Skrikhas, Catchamita, and Suffaida) appear to revert to polyembryony at least in a greater proportion, if not all, of their seeds when grown here. Amini seems to revert to polyembryony in Florida in 1914 (Rolfe, 1915), while Cambodiana and Bombay are reported polyembryonic too. The Bombay Yellow variety, however, is reported to be monoembryonic here in the Islands, a character which is rather unusual.

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[3] Information supplied by Mr. Francisco G. Galang, in charge of horticultural section of the Bureau of Plant Industry, Manila.

The peculiar performance of few Indian mangoes now growing in the Islands mentioned above certainly makes one wonder how this could be possible. Questions may, therefore, be asked: Is this reversion to polyembryony in few of their seeds the result of natural cross-pollinations between our native polyembryonic varieties and these Indian mangoes? If so, why is it that not all these Indian mangoes now growing in the Islands revert to polyembryony? Can this reversion be taken as an expression of the effect of environment on the plant itself, considering that the property of reversion is plastic and easily affected by the habitat? Will progenies of these reverting Indian mangoes when planted back in their home country give rise to monoembryonic or polyembryonic seeds? These questions are too interesting not to merit our closest attention, because their answer may settle once and for all which character, poly- or monoembrony, is the more primitive, and they may point to the possible origin of all present mangoes. However, going into the question of the origin of the mangoes in the Philippines is not within the scope of the present study.

It may, however, be said in passing that there seems to be a preponderance of opinion that the mango originated in India or somewhere in the Malayan region (DeCandolle, 1919; Popenoe, 1917; Wester, 1920). In a communication to the author, Mr. Bijhouwer seems to believe that there are two big centers of origin of the mango; one is India with monoembryonic mangoes, and the other is the area of Saigon, Dutch East Indies and the Philippines with polyembryonic mangoes.

SUMMARY

The embryo sac of carabao mango is believed to be normal and its endorsperm is of the nuclear type. An account of the behavior of the zygote is herein given.

The zygote usually persists in the embryo sac for a long time before dividing and forming sexual embryo, but it may degenerate and take no active part in the production of any embryo in the seed.

The adventive embryos in the seed are nucellar in origin and arise from active divisions of the epidermal nucellar cells around the micropylar end of the embryo sac.

The sexual embryo may develop ahead of the apogamic or adventive embryos, and is then the largest, although at times it may be outgrown by the adventive embryos, and hence it is hard, if not impossible, to distinguish the sexually produced embryo from the asexually formed embryos, even when the seed is young and immature.

There is an equal chance of having sexual or no sexual embryo in the mature seeds of carabao mango. At germination, the sexual embryo may be the largest among the sprouts if it gains ascendancy over the apogamic embryos, otherwise this rule will not hold true. Vigor is no criterion in discriminating the embryos.

Cases of reversion to polyembryony by monoembryonic imported Indian mangoes are presented and some probable causes suggested.

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EXPLANATION OF PLATES

PLATE 1

Fig. 1. Diagram of a longitudinal section of a young pistil some time after anthesis, showing the relative positions of the megasporange and the embryo sac (*es*); *fi*, fused integuments; *ne*, nectary; *ow*, ovary wall. × 26.

2. Detail of the contents of the embryo sac from fig. 1, showing the primary endosperm nucleus (*pen*), and the zygote (*zy*). × 890.

3. Showing contents of the embryo sac from a flower long after anthesis; *pen*, primary endosperm nucleus; *sy*, synergids; *zy*, zygote. × 890.

4. A more advanced stage of the content of the embryo sac; *pen*, primary endosperm nucleus; *sy*, synergid; *zy* zygote. × 890.

5. Contents of the sac from a flower at anthesis; *fn*, fusion nucleus; *me*, megagamete; *sy*, zynergid. × 1060.

6. Embryo sac from a young fruit (1.6 to 2.8 millimeters in diameter) showing the primary endosperm nucleus (*pen*), and the zygote (*zy*); *sy*, synergid. × 890.

7. Embryo sac from a flower at anthesis (see fig. 5 for comparison); *fn*, fusion nucleus; *me*, megagamete; *sy*, synergid. × 890.

8. Embryo sac from a young fruit (1.6 to 2.8 millimeters in diameter); *pen*, primary endosperm nucleus; *zy*, zygote. × 890.

9. Showing nuclear endosperm (*en*) and well developed zygote (*zy*). × 890.

10. Showing enlargement of a lateral nucellar cell from a young seed (3 to 5.3 millimeters long); note distinct vacuolation; *en*, endosperm. × 540.

PLATE 2

Fig. 11. Diagram of a longitudinal section of a young seed (5 millimeters long); *en*, endosperm; *f*, funiculus; *sc*, seed coat; *vb*, vascular bundle; *zy*, zygote. × 26.

12. Showing epidermal nucellar cells opposite the funiculus dividing periclinally (*ap*), while adjacent cells are in process of enlargement preparatory to formation of adventive embryos (taken from fig. 11); *en*, endosperm; *zy*, zygotes. × 1060.

13. Showing adventive embryo (*aem*) and sexual embryo (*sem*); *f*, funiculus; *sc*, seed coat; *vb*, vascular bundle. Note nearly identical size of the embryos. × 26.

14. Showing two embryos; *aem* adventive embryos; *sem*, sexual embryo; *sc*, seed coat; *vb*, vascular bundle; *f*, funiculus.

15. Showing a large sexual embryo (*sem*) and two small asexual or adventive embryos (*aem*). Taken from seed about 16 millimeters long. × 26.

16. Detail of two embryos which are nearly identical in size; *aem*, asexual or adventive embryos; *sem*, sexual embryo. Note nuclear endosperm (*en*). × 235.

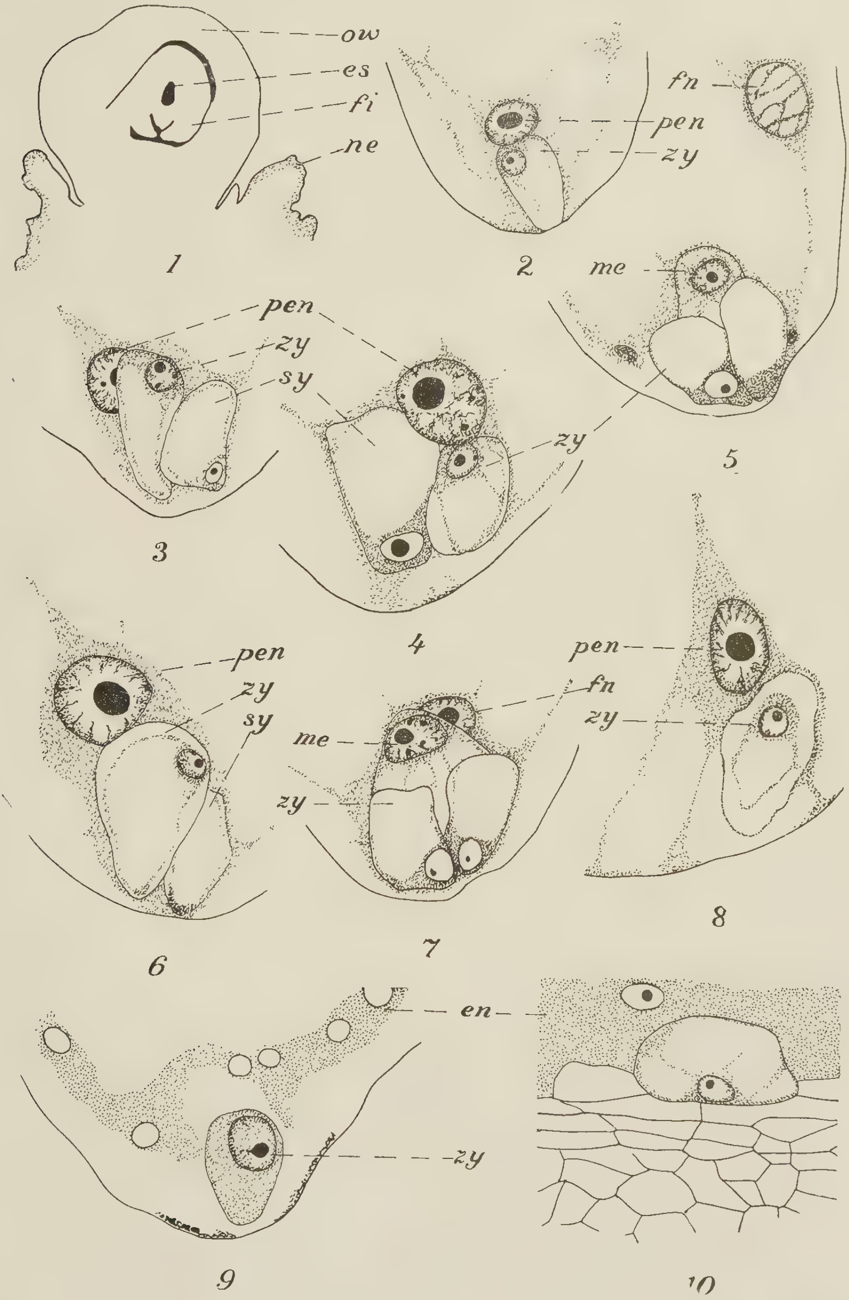
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PLATE 1

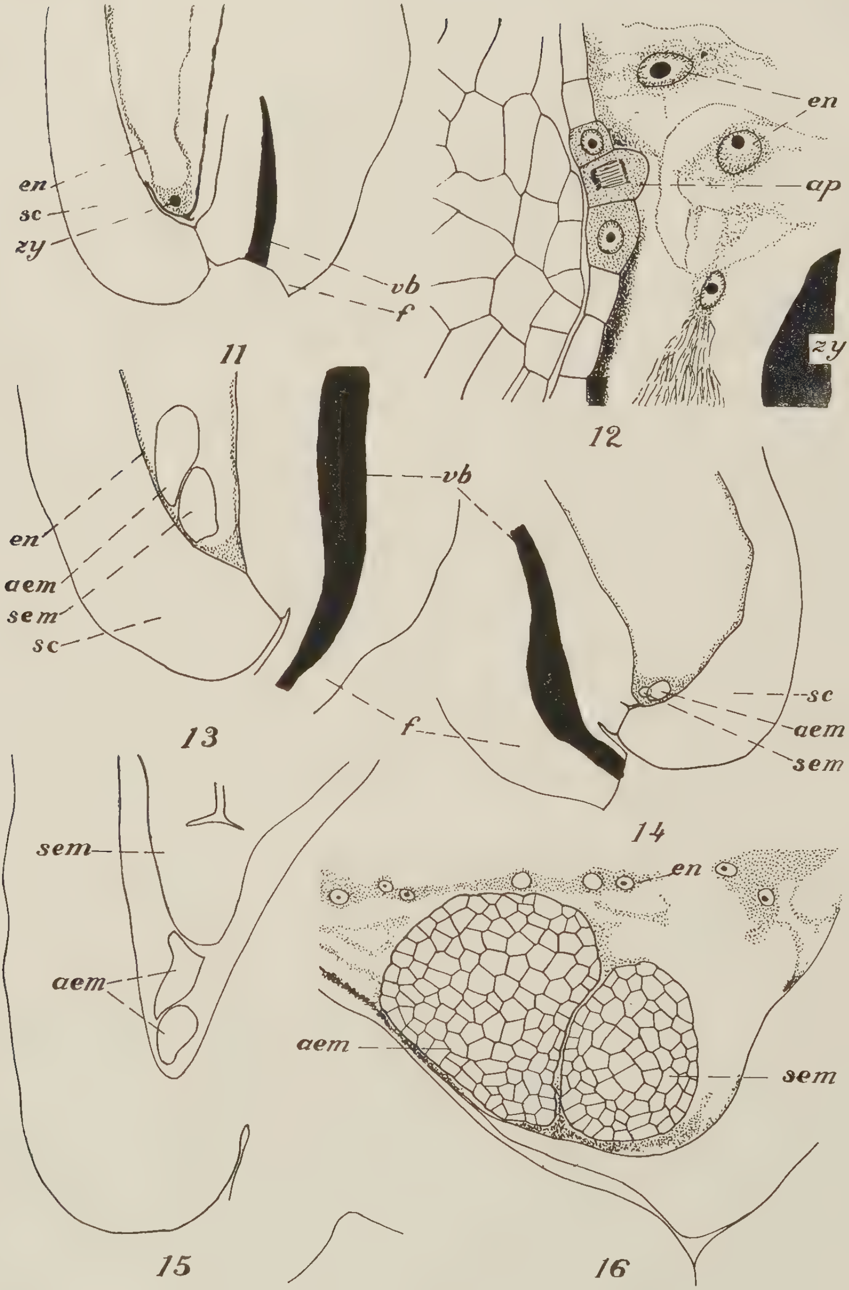
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PLATE 2

A BIOCHEMICAL ANALYSIS OF KANDULI (ARIUS SPP.) AT DIFFERENT AGES[1]

CESAR T. MAMON

Kanduli (*Arius* spp.), of the catfish group, occupies an important rôle in the diet of the people living near Laguna de Bay and in the neighboring provinces. Analysis of the amino-acid content of kanduli selected at random was made by Galvez and Santos (1932), but no work has been done on the amino-acid content of kanduli of different ages. Since kanduli is offered in the market in immature, mature and spent stages, it appeared interesting to have an approximate idea of the distribution of amino-acids in its three common marketable ages. This work was performed in the Department of Agricultural Chemistry from June, 1933, to February, 1934.

MATERIALS AND METHODS

The kanduli used in this work were bought in the barrio of Mayondon, Los Baños, Laguna. They were classified into three stages by Mr. Andres M. Mane of the Department of Entomology of this College.

Sampling. The edible portions of 101 immature, 60 spent, and 12 mature kanduli, were separated from the gills, intestines and bones and washed several times with distilled water. The flesh of males and females of the mature and spent fish was removed from the non-edible portions and each placed in a separate container. Owing to the difficulty in distinguishing males and females in the immature kanduli, the flesh of the 101 immature fish was mixed together. The samples were then run three times through a meat grinder and then dried in the sun. After drying, equal amounts of the flesh of the mature males and females were mixed. The same was done with the flesh of the spent. The amounts were calculated on a dry basis. The proximate chemical analyses of the sun-dried samples are given in table 1. The three resulting samples were ground separately to a fine powder and extracted thoroughly with ether. The fat-free samples were dried at room temperature to remove the ether and then placed in dried bottles. Each of the samples was mixed thoroughly before portions for analysis were taken.

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[1] Part of thesis presented for graduation, 1934, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 514; Experiment Station contribution No. 1158. Prepared in the Department of Agricultural Chemistry under the direction of Dr. F. O. Santos.

Total nitrogen. Total nitrogen of the fat-free samples was determined by the modified Kjeldahl-Guning-Arnold method. All total nitrogen determinations were made by this method.

Hydrolysis. A twenty-five gram portion of each of the prepared samples was weighed and hydrolyzed with 500 ml. 25 per cent hydrochloric acid. The hydrolysis was carried out by boiling the mixture in a 800 ml. Kjeldahl flask connected with a reflux condenser for 20 hours, after which the flask was removed and the amino-nitrogen was determined with Van Slyke's micro-apparatus from 1 ml. portion of the hydrolysate diluted to 10 ml. with water. The reaction of the sample and nitrous acid was allowed to proceed for five minutes standing and one minute shaking. Hydrolysis was again resumed and the amino nitrogen was determined at 10-hour intervals, until a constant reading of the nitrogen gas was obtained, after which hydrolysis was stopped. The hydrolysate was filtered and the residue washed thoroughly with distilled water and its total nitrogen was determined as insoluble humin. The filtrate and washings were combined and then diluted to 1000 ml. Aliquot portions of the hydrolysate were taken for total nitrogen and nitrogen distribution determinations.

(*1*) *Amide N.* Amide nitrogen was determined by the method used by Plimmer (1917). A 100-ml. aliquot of the hydrolyzed solution was placed in 1000 ml. Claisen distilling flask and made slightly alkaline with 10 per cent suspension of calcium hydrate. The resulting solution was distilled in vacuo at 35°C. until it was about 10 ml. The ammonia vapor was collected by passing it into standard acid and after the process the excess acid was titrated with standard alkali for the determination of amide nitrogen.

(*2*) *Humin N.* Humin was determined by the method of Plimmer (1917). The black coloring matter absorbed by the lime was filtered and washed several times with distilled water until free from chlorides. The precipitate and paper were then submitted to Kjeldahl analysis.

(*3*) *Total N of diamino fraction.* The combined filtrate and washings from the humin precipitate was evaporated under a diminished pressure until the volume was reduced to approximately 100 ml. The resulting solution was then acidified with 10 ml. concentrated hydrochloric acid, precipitated with 15 grams phosphotungstic acid, stirred and the precipitate allowed to settle. The clear solution above the precipitate was tested for complete precipitation of the diamino fraction. The mixture was then heated in a water bath until the precipitate was nearly redissolved. After standing for 48 hours, the precipitate was filtered in a 3-inch Buchner funnel with a hardened filter paper. Washing was effected with 10 ml. of a solution containing 2.5 grams of phosphotungstic acid and 3.5 grams of hydrochloric acid per 100 ml.; this was repeated several times until the washings gave a negative test for calcium. The precipitate was then dissolved in N sodium hydroxide and the volume made up to 250 ml. in a graduated volumetric flask. Total nitrogen of the diamino fraction was determined by taking 50 ml. aliquot of the dissolved phosphotungstates.

Arginine value was determined by the method of Plimmer (1916). A 25 ml. portion of the solution of the diamino fraction was boiled for six hours with an equal volume of 40 per cent sodium hydroxide in a 200 ml. flask connected with a water condenser and a Folin bulb containing 10 ml. standard acid solution, after which, the condenser was emptied. Boiling was further continued for 30 minutes to drive out the arginine nitrogen that might be present in the condenser. The excess acid in the receiver was transferred to a beaker and titrated with standard alkali solution. The decrease in amount of the acid used corresponds to the amount of arginine nitrogen in the 25 ml. portion of the sample in the diamino fraction.

The value of histidine was calculated from the relation (Plimmer 1917: histidine nitrogen = $3/2$ (D — $\frac{3}{4}$ arginine), where D is the non-amino nitrogen which is obtained by subtracting amino-nitrogen from the total nitrogen of the diamino fraction.

The determination of cystine was made by the method of Plimmer and Lowndes (1927). The solution of cystine phosphotungstate (25 ml. of diamino fraction) was evaporated to dryness with 10 ml. Benedict-Denis reagent on a hot plate until distinct charring was seen. The residue was then heated over a flame for 15 minutes. The oxidized material was boiled with 25 ml. HCl. After standing overnight the solution was filtered from the insoluble tungstic oxide through a 9 cm. hardened paper and the precipitate washed with 50 ml. of hot concentrated hydrochloric acid and then with hot 50 per cent hydrochloric acid. The solution was diluted with 200 ml. of water. The yellow precipitate which appeared on warming was filtered off and washed with dilute hydrochloric acid (1:1). The clear solution was precipitated with barium chloride. In this investigation no barium sulfate precipitate was formed, probably because there was no cystine in the sample analyzed. Several determinations were made with negative results.

Lysine was calculated from the values of histidine, arginine and cystine already found (Plimmer, 1917). Lysine N = Total N of diamino fraction — (arginine N + cystine N + histidine N).

The amino nitrogen in the diamino fraction was determined by the reaction of nitrous acid for one hour using Van Slyke's micro-apparatus as described by Plimmer, (1917).

(4) *Total nitrogen of mono-amino fraction.* The filtrate and washings from the phosphotungstate precipitate was diluted to 500 ml. in a graduated flask. Total nitrogen was then determined using 50 ml. portion.

The amino-nitrogen determination in the mono-amino fraction was made at room temperature by the reaction of nitrous acid for one-half hour in Van Slyke's micro-apparatus as described by Plimmer (1917).

Non-amino nitrogen was found by subtracting the amino nitrogen of the mono-amino fraction from the total nitrogen of the mono-amino fraction already found.

(5) *Total nitrogen recovered.* Total nitrogen recovered was calculated by summing up the values obtained for amide N, humin N, Total N of diamino fraction and total N of the mono-amino fraction.

RESULTS AND SUMMARY

The results of this work are shown in table 2. For purpose of comparison the findings of Galvez and Santos (1932) on kanduli, with the results of Biboso (1933) on the amino acid content of dalag, biyang-puti, and bañgos and of Rosedale (1929) on the diamino acid content of four commercial Singapore fishes are also shown.

The nitrogen distribution in proteins of the three kinds of kanduli studied compares favorably with the nitrogen distribution in red snapper (*Ikan Merah*), thread fin (*Senangin*), thread fin (*Kuraw*) and carp (*Twatow*), biyang puti, dalag, and bañgos. Cystine N was not obtained.

Proximate analysis (table 1) shows that spent kanduli contains less fat but more protein than both the mature and the immature ones.

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TABLE 1

Proximate chemical analysis of immature, mature, and spent kanduli[1]

	IMMATURE	MATURE	SPENT FISH
	per cent	*per cent*	*per cent*
Moisture	10.74	13.65	7.02
Fats (ether extract)	13.99	14.12	12.71
Ash	4.68	5.65	4.54
Protein	67.63	66.45	69.55
Crude fiber	—	—	—
Carbohydrates (N. F. E.)	2.96	0.13	6.18
Cal. /100 g.	420	405	430

[1] Analysis made by the Experiment Station Section of the Department of Agricultural Chemistry. Sun-dried samples were used.

TABLE 2

Nitrogen distribution in immature, mature, and spent kanduli and in seven other fishes

	IMATURE			MATURE			SPENT FISH			ARIUS SPP. (KANDULI)		
		per cent			*per cent*			*per cent*			*per cent*	
T. N. of fat-free sample ..		12.13			12.50			11.98				
T. N. of the hydrolysate ...		12.07			12.43			11.86				
Amide N	8.92			7.89			8.53			6.10		
Humin N	1.38			1.63			1.42			1.20		
T. N. of di-amino fraction .	32.00			32.92			34.32			49.60		
Arginine N			8.13			8.48			8.31			15.80
Histidine N			19.04			19.57			22.45			20.20
Cystine N			—			—			—			—
Lysine N			4.83			4.87			3.77			10.90
Amino N		13.22			13.80			13.26			21.60	
T. N. of mono-amino fraction	59.08			60.32			62.27			45.40		
Amino N			53.61			57.04			58.13			41.70
Non-amino N			5.47			3.27			4.13			3.70
T. N. recovered	101.38			102.76			106.54			99.60		

TABLE 2 Continued

	CHANOS CHANOS FORSKÁL (BAÑGOS)		GLOSSOGOBIUS GIURUS HAM.-BUCH. (BIYANG-PUTI)		OPHICEPHALUS STRIATUS BLOCH (DALAG)		RED SNAPPER (IKAN MERAH)	
	per cent		*per cent*		*per cent*		*per cent*	
T. N. of fat-free sample ..								
T. N. of the hydrolysate ...								
Amide N.	7.20		7.70		6.60		8.00	
Humin N	1.80		1.03		1.10		1.00	
T. N. of di-amino fraction .	32.16		33.74		37.34		31.00	
Argine N		11.33		11.04		11.14		16.00
Histidine N		8.75		8.80		15.14		2.00
Cystine N		—		—		—		—
Lysine N		12.06		13.34		13.03		10.00
Amino N	13.26		19.50		20.40		23.00	
T. N. of mono-amino fraction	61.28		58.82		56.42		65.00	
Amino N		54.66		51.31		48.10		62.00
Non-amino N		8.38		7.51		8.32		3.00
T. N. recovered	102.44		101.29		101.46		105.00	

TABLE 2 Continued

	THREAD FIN (SENANGIN)	THREAD FIN (KURAW)	CARP (TWATOW)
	per cent	*per cent*	*per cent*
T. N. of fat-free sample			
T. N. of the hydrolysate			
Amide N	7.00	8.00	7.00
Humin N	1.00	2.00	1.00
T. N. of di-amino fraction	28.00	27.00	27.00
Arginine N	14.00	12.50	12.00
Histidine N	5.50	7.00	6.00
Cystine N	—	—	—
Lysine N	8.00	11.00	7.00
Amino N	22.00	18.00	17.00
T. N. of mono-amino fraction	62.00	63.00	63.00
Amino N	60.00	54.00	61.00
Non-amino N	2.00	9.00	2.00
T. N. recovered	98.00	100 00	98.00

THE INFLUENCE OF WITHOLDING FEEDS FROM NEWLY HATCHED CHICKS [1]

F. M. FRONDA, FELIPE T. BAÑEZ, AND GREGORIO A. MONEGAS

Chicks are known to be able to live for a number of days with neither food nor water, but how long they can without being seriously affected has not yet been studied in the Philippines. Such information is important in the baby chick industry, the possibilities of which should be studied in this country. The baby chick producer must necessarily engage in the shipping of baby chicks to his customers. He should know, therefore, how long chicks after they are removed from the incubator can exist in fair condition without feed and water. These studies were conducted to acquire some knowledge on this important question. The experiments were conducted in the poultry laboratory of the Department of Animal Husbandry, College of Agriculture, from March, 1932, to January, 1933, and from September, 1933, to August, 1934.

Review of literature

Regarding the feeding of newly hatched chicks, Lamon (1918), Lee (1920), Fronda (1928), and Jull (1930) recommend that chicks should not be fed until they are 24 to 48 hours old. Lee (1920) claimed that the yolk of the egg which is absorbed by the chick just before hatching furnishes all the nourishment required for the first two days of its life. Alder (1924), Vandervort (1925), and Clickner (1927) extend this limit of withholding feed from 48 to 72 hours after hatching. They warn that feeding chicks too soon and over-feeding them causes many losses and stunted growth. They claim that there is the unabsorbed yolk in the chicks' bodies and unless this is at least partially used up before feeding them, digestive troubles are likely to result.

But Schilling and Bleecker (1928) found that the intake of feed did not influence the rate of the disappearance of the yolk. Malarski (1922), as cited by Parker (1929), recommended the feeding of

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[1] The data presented in this paper were taken from the theses prepared for graduation, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture, University of the Philippines, by Gregorio A. Monegas, '34, No. 515, and Felipe T. Bañez, '35, No. 516; Experiment Station contribution No. 1159.

Received for publication July 20, 1936.

chicks as soon as possible after hatching and Roberts (1928) after conducting experiments on the same subject, concluded that chicks may be fed as soon as they are hatched without adversely influencing rate of growth or mortality. Roberts, however, added that early feeding of chicks had no advantage over the old method of withholding the feed for 48 hours or more.

According to Parker (1929) a variety of early handicaps including poison, starvation, and high and low temperature failed to alter markedly the course of yolk absorption in baby chicks and, in general, to produce permanent effects in the body weights.

PLAN OF STUDY

In the first part of these studies conducted from March, 1932 to January, 1933, six lots each consisting of 119 Los Baños Cantonese chicks, except one lot, lot 6, which had only 79 chicks, were used. Five sets of observations were made and each lot was treated as follows:

LOTS	LENGTH OF STARVATION PERIOD	NUMBER OF CHICKS					TOTAL
		Hatch I	Hatch II	Hatch III	Hatch IV	Hatch V	
	hours						
1	0	24	36	19	15	24	119
2	24	24	36	19	15	24	119
3	48	24	36	19	15	24	119
4	72	24	36	19	15	24	119
5	96	24	36	19	15	24	119
6	120	0	36	19	0	24	79

In the second part, conducted from August, 1933 to January, 1934, only three sets of observations were made, and only four lots each containing 93 Los Baños Cantonese chicks were used. The following table shows the number of chicks in each lot of the three hatches made, and the treatment of each lot:

LOTS	LENGTH OF STARVATION PERIOD	NUMBER OF CHICKS			TOTAL
		Hatch I	Hatch II	Hatch III	
	hours				
1	0	38	28	27	93
2	24	38	28	27	93
3	48	38	28	27	93
4	72	38	28	27	93

The object of the first part was to determine how many days after removal from the incubator can baby chicks stand starvation without serious effects. The second part was carried through to the time when the pullets have laid their first eggs, to see if the length of the starvation period had any effect on the rate of growth and the length of maturity of the pullets.

After the chicks had been legbanded, they were divided into lots and placed in separate boxes of equal dimensions constructed in such a way that they appeared like baby chick shipping boxes. They were brooded in fireless brooders. A starting ration consisting of corn meal mixed thoroughly with fresh eggs, one egg for every thirty chicks a day, was used for the first four days of feeding. Then a chick mash made up of two parts shrimp meal, two parts corn meal and six parts rice bran was given to them. During the first four weeks the chicks were provided with finely chopped green grass at least three times a week. After this period they were allowed to run in the grassy yard. Grit and clean fresh water were provided at all times.

Records. The chicks were weighed daily during the first week of age to determine the loss of weight of the chicks during the starvation period and the gain made after giving them their feed and water. The chicks in the second part were weighed daily during the first week, then weekly up to weaning at the age of three months, and every two weeks thereafter to maturity. Mortality rcords were kept. The dates when the pullets laid their first eggs were carefully observed and recorded.

RESULTS AND DISCUSSION

Profitable starvation period. The "starvation period" as used in this paper means the time between actual removal of the chicks from the incubator and the giving of the first feed and water. The chicks were removed from the incubator when a majority of them were already dry. The chicks in the check lot, lot 1, were immediately given feed and water and those in lot 2, twenty-four hours later, those in lot 3, forty-eight hours later, etc.

Table 1 gives the number of chicks, expressed in per cent of the total at the start, in the lots differently treated. By reference to this table it may be seen that feed and water may be withheld from newly hatched chicks without much loss up to the forty-eighth hour after hatching. Beyond this limit, considerable losses were noted. It may also be noted in the table that the longer the chicks were starved, the higher was the mortality.

Contrary to expectations, no ill effects resulted in the feeding of the chicks immediately after their removal from the incubator.

The results obtained in lot 1 (fed immediately) and in lot 2 (fed 24 hours later) are about the same. Basing from the number of chicks alive at the end of the first week, it may be concluded that, under the conditions in which this study was made, it will not pay to withhold feed and water from newly hatched chicks longer than forty eight hours after removal from the incubator. These results corroborate those of Heywang and Jull (1930) who concluded that it is probably true that feeding chicks early has slight effect on the rate of assimilation of the yolk in day-old chicks and that early feeding is not harmful.

Loss of weight of chicks due to starvation. Table 2 gives the weight of newly hatched chicks that had been subjected to varying lengths of starvation. By reference to this table, it may be seen that none of the chicks in which the feed was withheld for 120 hours or five days after removal from the incubator were able to survive the period of starvation. As was to be expected, the longer the period of starvation, the more was the amount of weight lost. Apparently, the rate of loss of weight was, however, not much influenced by the length of the starvation period, for the chicks that were starved for only 24 hours lost an average of 2.25 grams in weight and those in which the feed was withheld for 96 hours lost an average of 2.22 grams. A similar tendency was observed among the starved chicks used in the second part of these studies, although the amount of weight lost in this case was not as much as that in the first part. Differences in the condition of the weather may have been responsible in the differences in the amounts of weight lost by the chicks in the first and second parts of these studies.

Daily weights of starved chicks. The daily weights of the starved chicks during the first seven days of age are given in table 3. Only the first four lots were studied as it was thought unwise to keep the chicks without feed longer than 72 hours after removal from the incubator.

By reference to this table, it will be seen that all the chicks in the starved lots began to increase in weight rapidly after eating their first feed. Within certain limits, the chicks that had been starved can increase in weight without any break, if given good care and management, although the average weights of the chicks in the starved lots at the end of the first week were less than that of the control lot. It may be noticed also from these figures that the longer the period of starvation, the smaller were the chicks at the end of the first week. Another striking feature of these data is that, of all the lots, lot 4, starved for 72 hours, had the smallest number of chicks, only 42 chicks were left at the end of seven days, and lot 2, starved for 24 hours, had the most, 74 chicks. The mortality from the time the chicks received their first feed and water up to the end of the first week may have been due either to the quality of the starting ration used, to weak constitution caused by starvation, or to both. These are problems for future study.

Effect of starvation on rate of growth of the pullets. Table 4 shows the average weight of the pullets in the control and experimental lots at bi-weekly intervals. At the age of two weeks, lot 1 had already a weight heavier than the other lots. This condition was maintained up to the eighth week. At the age of ten weeks the pullets in lots 2 and 3 (starved lots) became heavier although not significantly so than those of lot 1 (unstarved lot). And by the twelfth week, the pullets in lot 4 (72 hours starved) were heavier than those of lot 1. In the eighteenth week, however, the average weights of the pullets in the different lots stood as follows: lot 1, second; lot 2, third; lot 3, fourth; and lot 4, first. From the eighteenth week to the end of the experiment, the birds in all the lots continued to increase in weight, until at the end of the experiment when the pullets of lot 4 were the heaviest; those of lot 2, second; those of lot 1, third; and those of lot 3, fourth.

Although the differences in weight at the end of the twenty-sixth week were not significant when treated biometrically, still, the fact that the pullets in the lot that was subjected to the longest period of starvation were not inferior, is significant in showing that withholding feed is not a handicap in the rate of growth among birds that survived the test. It appears that the birds left in lot 4 (starved 72 hours) were more vigorous and more hardy than the birds of any of the first three lots, as the weaker individuals had been eliminated or killed off during the early period of starvation. It is evident that a stock of animals of superior vigor can be formed by this method.

Mortality of the chicks in each lot. From the average of the mortality during the brooding period (see table 5) it could be seen at the end of the period that in all the trials, lot 1 had 23.37 per cent mortality; lot 2, 31.29 per cent; lot 3, 49.08 per cent; and lot 4, 71.61 per cent. From these figures, it is evident that the longer the starvation period, the higher the mortality during the brooding period. Also, apparently, feeding baby chicks as soon as they are removed from the incubator did not cause heavy mortality as claimed by Vandervort (1925). In the commercial production of poultry it would seem best to feed chicks soon after hatching as this practice results in the lowest mortality during the brooding period.

The average of the rearing mortality in the three trials, lot 1 had 8.46 per cent; lot 2, 11.43 per cent; lot 3, 19.70 per cent; and lot 4, 3.70 per cent. It may be mentioned in this connection that the rearing mortality of lot 4 (starved 72 hours) was much lower than that of lot 1. There were fewer pullets in this lot than in the other lots but these few survived to the end of the experiment. Combining the mortality during the breeding and rearing periods in all the lots in the trials made, it is very evident that the longer the starvation period, the higher is the mortality rate.

Influence on the health, vigor and maturity of the pullets of withholding feeds. Table 6 shows the ages at which sexual maturity was reached by the birds in the different lots. Referring to this table, it may be seen that one pullet in lot 1 and also one in lot 4 laid their first egg between the ages of 121-130 days; one in lot 1 maturing in 129 days and the one in lot 4 in 130 days. Also, between 131 and 160 days 14 pullets of lot 1 laid their first egg; in lot 2, 9 pullets; in lot 3, 10 pullets; and lot 4, 4 pullets. In lot 1 (control) it took 157.4 days for the pullets to mature; those in lot 2, 157.2 days; those in lot 3, 154.3 days; and those in lot 4, 159.1 days. When treated statistically the differences in the number of days to bring the pullets to maturity were found insignificant. It may be safe to conclude, therefore, that withholding feeds from newly hatched chicks for as long as 72 hours did not have any effect on the maturity of the pullets.

According to Lippincott (1927), the rate of maturity is influenced by the ration, weather conditions, and the condition of summer range, feed being the most important factor. Lippincott also stated that egg laying may be forced by increasing the amount of protein in the ration given. The mash ration used throughout the present experiment, which was composed of 2 parts shrimp meal, 2 parts corn meal, and 6 parts rice bran, and considered as a forcing ration may partly account for the early maturity of the pullets. It should, however, be borne in mind that the stock used in the experiment came from pens which were selected for early maturity.

Ordoveza (1927) reports that chicks hatched during December matured early. He found that the earliest laying pullet laid her first egg when she was only 145 days old. This finding offers an additional reason for the early maturity of the pullets in this experiment as hatches 1 and 2 were on December 6, 1933 and January 1, 1934, respectively. The third hatch was on May 22, 1934. Fronda and Enriquez (1935) observed that some of the pullets in the lot where there was no cockerel, began to lay their first egg at the age of 160 days. Tioaquen (1933) found that the age of earliest maturing Los Baños Cantonese birds varied from 140 to 176 days.

SUMMARY AND CONCLUSIONS

The influence of withholding feeds from newly hatched chicks was studied and the results obtained may be summarized as follows:

1. It is not advisable to withhold feed and water from newly hatched chicks longer than forty-eight hours after removal from the incubator.

2. The longer the period of starvation, the greater was the amount of weight lost. The daily rate of loss of weight was, however, not apparently influenced by the length of the starvation period.

3. Within certain limits, the chicks that had been starved were able to increase in weight, although the starved chicks were significantly smaller than those unstarved at the end of the first week.

4. At the age of twenty-six weeks, the pullets from the lot that was subjected to the longest period of starvation were not inferior in size to the other pullets.

5. Withholding feed from the chicks for 72 hours after removal from the incubator was not a handicap to the growth of chicks which survived the period of starvation after the tenth week. It is possible that a stock of superior vigor for breeding purposes may be formed by this method.

6. It was observed that the longer the starvation period the higher was the rate of mortality.

7. Starvation did not retard the age of sexual maturity of the birds.

8. From the results obtained in this study, it appears that shipping baby chicks to places that can not be reached within forty-eight hours is not advisable under local conditions.

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TABLE 1

Showing the number of chicks present in the different lots studied during the period that food and water were withheld from them. (Average of five trials)

AGE	LOT 1	LOT 2	LOT 3	LOT 4	LOT 5	LOT 6
	Feed not withheld	Feed withheld 24 hrs.	Feed withheld 48 hrs.	Feed withheld 72 hrs.	Feed withheld 96 hrs.	Feed withheld 120 hrs.
days	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	100	100	100	100	100	100
2	100	100 [a]	100	100	100	98.5
3	98.9	95.7	100 [a]	98.9	100	98.5
4	96.8	94.7	97.8	93.6 [a]	88.3	92.3
5	94.7	89.4	89.4	80.8	76.6 [a]	66.1
6	85.1	86.2	81.9	57.4	28.7	49.2 [a]
7	85.1	85.1	71.2	48.9	2.1	0

[a] The chicks were allowed access to feed and water.

TABLE 2

Showing the loss of weight of newly hatched chicks as influenced by starvation. Average of the five trials.

LOT NO.	LENGTH OF STARVATION PERIOD	WEIGHT OF CHICKS		DECREASE IN WEIGHT
		When taken down from incubator	After the starvation	
	hours [a]	*grams*	*grams*	*grams*
1	0	28.23	28.23	—
2	24	28.15	25.90	2.25
3	48	28.16	23.93	4.23
4	72	28.14	21.61	6.53
5	96	28.12	19.25	8.87
6	120	27.48 [b]	— [c]	--

[a] Number of hours after taking down from the incubator, when the chicks were 24 hours old after being hatched.

[b] Average of 3 hatches only.

[c] None survived the starvation period.

TABLE 3

Showing the weights of chicks in the control and experimental lots during the period of seven days. (Average of three hutches.)

AGE OF CHICKS	LOT 1 (NOT STARVED)		LOT 2 (STARVED 24 HOURS)		LOT 3 (STARVED 48 HOURS)		LOT 4 (STARVED 72 HOURS)	
	Number of chicks	Average weight of chicks	Number of chicks	Average weight of chicks	Number of chicks	Average weight of chicks	Number of chicks	Average weight of chicks
		grams		*grams*		*grams*		*grams*
Initial (1)	93	30.1	93	29.8	93	30.4	93	29.2
2	78 [a]	32.0	91	28.7	92	28.5	90	28.1
3	75	33.9	76 [a]	32.1	91	27.3	87	27.0
4	75	35.3	76	34.9	76 [a]	30.9	80	25.9
5	75	35.4	74	34.4	72	33.3	59 [a]	28.4
6	72	37.9	74	35.5	69	34.7	45	31.3
7	71	40.0	74	36.2	69	35.4	42	32.9

[a] 15 chicks were killed for the examination of the yolk for use in a separate study.

TABLE 4

Showing the weights of pullets in the control and experimental lots
(Average of three hatches.)

biweekly	LOT 1		LOT 2		LOT 3		LOT 4	
	Number of chicks	Average weight of chicks	Number of chicks	Average weight of chicks	Number of chicks	Average weight of chicks	Number of chicks	Average weight of chicks
		grams		*grams*		*grams*		*grams*
2	32	30.0	18	29.2	16	29.9	11	31.0
4	32	103.9	18	101.1	16	93.9	11	94.8
6	32	186.4	18	181.6	16	173.0	11	174.6
8	32	294.3	18	281.6	16	250.5	11	237.5
10	32	361.8	18	370.1	16	395.8	11	318.7
12	32	443.8	18	468.3	16	470.5	11	475.0
14	32	633.0	18	603.8	16	614.3	11	562.3
16	32	740.5	18	693.8	16	723.0	11	755.0
18	32	875.5	18	853.8	16	845.5	11	880.5
20	32	1034.9	18	1000.5	16	1016.1	11	964.1
22	32	1102.1	18	1058.8	16	1034.8	11	1089.1
24	32	1169.3	18	1111.6	16	1072.3	11	1107.3
26	32	1103.6	18	1108.8	16	1078.6	11	1134.6

TABLE 5

Showing the percentage of mortality during the brooding period (second part)

LOT NO.	TRIALS			AVERAGE
	I	II	III	
1	3.03	30.43	36.36	23.27
2	18.18	34.78	40.91	31.29
3	27.27	60.87	59.09	49.08
4	54.55	73.91	86.36	71.61

TABLE 6

Showing the ages of sexual maturity of the birds in the different lots. (Average of three hatches.)

DAYS TO MATURITY	LOT NUMBER			
	1	2	3	4
121–130	1	—	—	1
131–140	4	4	3	1
141–150	9	4	6	1
151–160	1	1	1	2
161–170	10	4	4	3
171–180	5	4	1	2
181–190	2	1	—	1
191–200	—	—	1	—
Total	32	18	16	11
Mean (days)	157.4	157.2	154.3	159.1

A STUDY OF DIFFERENT VARIETIES OF CASSAVA FOR HOG FEEDING PURPOSES[1]

MIGUEL G. ALBA

Feeding trials conducted in the College of Agriculture and elsewhere have shown that cassava may be utilized to great advantage by feeding it to hogs. There are, however, numerous varieties of cassava grown in the Philippines, some of which are more or less poisonous. It is possible that certain poisonous varieties have greater feeding value than others. It is the purpose of this study to throw light on these points.

Review of literature

Mondoñedo and Bayan (1927) fed for 70 days two lots of three-month old pigs on camote pasture, one on a ration containing 30 per cent corn and the other on the same ration with corn replaced by cassava on the basis of 1 part corn to 2 parts casava in cooked form. Both lots made an average daily gain of 0.21 kgm. per pig. The corn-fed pigs required 2.89 kgm. of feed, and the cassava lot 2.65 kgm. to make a kilogram gain in weight. With pigs at six months of age, fed in dry lot for 70 days, the animals in the cassava lot made an average daily gain of 0.18 kgm. and those in the corn lot, 0.14 kgm. The cassava-fed pigs required 6.82 kgm. feed and the corn-fed pigs 6.87 kgm. for every kilogram of gain. Therefore two parts of peeled cassava had a feeding value equal to one part of corn.

Mondoñedo (1928) made another study on the feeding value of corn and cassava as feeds for hogs. One lot of 8-month old pigs was fed with a ration containing 20 per cent corn, in the other lot corn was replaced by twice its weight of peeled, raw (chopped) cassava. The cassava lot made an average daily gain per pig of 0.40 kgm.; the corn lot, 0.36 kgm. The cassava lot required 0.44 kgm. more feed to make a kilogram gain than the corn lot. The varieties of cassava used were Kapo White and Angular. There was no evidence of poisoning with the varieties of cassava used.

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[1] Thesis presented for graduation, 1933, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 517; Experiment Station contribution No. 1160. Prepared in the Department of Animal Husbandry under the direction of Dr. Mariano Mondoñedo.

Mondoñedo and Alonte (1931) compared the feeding value of cassava with corn, sweet potato, and pongapong as feeds for hogs. The feeding period was 70 days. The average age of the pigs was two months. The basic ration consisted of 25 parts corn, 50 parts rice bran, and 25 parts copra meal. Lot I was fed with the basic ration mixture; the second, third and fourth lots were fed with the same basic ration except that the 25 parts corn were replaced by cassava in lot II, sweet potato in lot III, and pongapong in lot IV, double the amount or 50 parts in each case. From the point of view of rate of gains made compared with corn, the cassava lot averaged 90 per cent efficient; the sweet potato lot, 88 per cent; and the pongapong lot 69 per cent. The amount of feed consumed to make a kilogram gain was 7.07 kgm. for the corn lot, 9.27 kgm. for the cassava lot, 8.64 kgm. for the sweet potato lot, and 9.80 kgm. for the pongapong lot. In this experiment, therefore, 3.0 parts cassava, 2.6 parts sweet potato and 3.4 parts pongapong were equivalent to one part corn.

Mendiola (1931), in an article on the growing of cassava in the College of Agriculture, gave the quality of roots of the different varieties of cassava found in the Philippines (after boiling) as follows:

VARIETY	POISONOUS NATURE AFTER COOKING	FLAVOR
Mandioca Sao Pedro Preto	Very poisonous	Not edible
Mandioca Basiorao	Not poisonous	Fair
Aipin Valenca	" "	Good
Aipin Mangi	" "	Very good
Casjave Singkong Manis	" "	Very good
Kapo White	" "	Good
Kapo Colorado	" "	Fair
Rough Intermediate	" "	Good
White Smooth Intermediate	" "	"
Aipin Trapecuma	" "	"
Mandioca Itaparica	" "	"
Mandioca Tapicuru	" "	Fair
Mandioca Criolinha	Poisonous	Not edible
Aipin Manteiga	Not poisonous	Good

Adriano, Ramos and Ynalvez (1932), gave the proximate analysis of different varieties of cassava grown in the College of Agriculture. The varieties of cassava analyzed were Aipin Mangi, Aipin Valenca, Kapo White, Angular, Casjave Singkong Manis, Mandioca Basiorao, Mandioca Sao Pedro Preto, and Rough Intermediate. The average proximate chemical analysis of these different varieties of cassava are as follows:

COMPOSITION	PERCENTAGES
Edible portion	81.40
Moisture	63.80
Ash	1.44
Proteins	0.96
Fats, Ether Extract	0.26
Hydrocyanic acid	0.02
Crude fiber	0.85
Starch	27.65
Other N. F. E.	5.04
Calorific value per kgm.	1,403.00

The average percentage or proportion of refuse to edible part of the root is approximately 1:4.

Camus (1914) reported on the amount of hydrocyanic acid present in the roots of some local cassava grown on the College Farm. The following were the results of his analyses:

CONSTITUENTS	WHITE PETIOLED VARIETY	RED PETIOLED VARIETY	INTERMEDIATE VARIETY
	per cent	*per cent*	*per cent*
HCN (bark)	0.043	0.046	0.048
HCN (Edible portion)	0.032	0.028	0.023

From the analysis he pointed out that 0.04 grams of HCN is probably the fatal dose for a human being. Even half this amount might produce serious results. Therefore, if an adult should eat as little as 140 grams of the red petioled variety which contains 0.028 per cent of HCN, fatal results might follow were it not for the fact that the HCN is expelled during the process of boiling.

Copeland (1908) reports that in the same plant the amount of poison is not likely to be the same in all parts. The part of the root which contains dangerous amounts of HCN is the thin, dark bark as well as the cortex. Aside from the free HCN that is present in the roots, there is also that poison that combines in the form of glucoside. This glucoside breaks down when the dug roots decay and thus liberates the HCN. Hence, decayed cassava roots should not be used for food. Even with hogs, decayed cassava roots were found to be fatal. It was reported in New Caledonia that cassava roots three days after being dug were fatal to hogs.

Sison (1921), made a comparative test of the texture and palatability of boiled roots of different varieties of cassava raised on the College Farm. The results of his test were as follows:

VARIETY NAME	SWEET OR BITTER	PALATABLE OR NOT PALATABLE	FIBROUS OR NOT FIBROUS
Rough Intermediate ...	Sweet	Sticky and glutinous	Fibrous
Kapo White	"	Palatable	Not very fibrous
Mandioca Basiorao	"	Very palatable	Very fibrous
Casjave Singkong Manis	"	Very palatable	Very fibrous
Aipin Valenca	"	Palatable	Not very fibrous
Angular	"	Not very palatable	Fibrous

The following is the analysis of the whole root of cassava for seven varieties for their HCN content. These analyses were made in the Experiment Station, Department of Agricultural Chemistry:

Kapo White	0.008	per	cent	HCN
Casjave Singkong Manis	0.010	"	"	"
Mandioca Tapicuru	0.010	"	"	"
Mandioca Itaparica	0.008	"	"	"
Mandioca Basiorao	0.012	"	"	"
Aipin Valenca	0.010	"	"	"
Angular[2]	0.002	"	"	"

There is no analysis of Leyte Unknown and Rough Intermediate varieties because there were no roots available at the time the analysis was made.

Objects of the present work

This work was conducted primarily: (*a*) to determine whether or not certain varieties of cassava have any poisonous effects on pigs; (*b*) to determine the effect of varying amounts of cassava on the growth of pigs; (*c*) to determine whether or not certain varieties are better than others for hog feeding purposes.

Time and place of the present work

This work was conducted in the Department of Animal Husbandry, College of Agriculture, University of the Philippines. The work was divided into four experiments. The first experiment was carried from October 26, 1931 to January 4, 1932; the second experiment from January 12 to March 28, 1932; the third experiment from January 25, 1933 to April 5, 1933; each experiment covered a period of 70 days; the fourth experiment was carried from April 20 to May 25, 1933 covering a period of 31 days.

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[2] Analysis taken from Alzona (1933), on a field test of twenty varieties of cassava.

MATERIALS AND METHODS

Materials

Animals used. The animals used in this experiment were Berkjala pigs raised in the Department of Animal Husbandry. The pigs used in experiment I were about three and a half months old; in experiment II, about nine months old; in experiment III, five and a half months old; and in experiment IV, yearlings. All the pigs used in each experiment were fairly uniform in size and were rather spare in condition.

Feeds. The feeds used in this experiment consisted of rice bran, corn, copra meal, shrimps and cassava roots. Nine varieties of cassava were used. They were Rough Intermediate, Kapo White, Leyte Unknown, Angular, Casjave Singkong Manis, Mandioca Basiorao, Aipin Valenca, Mandioca Itaparica, and Mandioca Tapicuru. The average cost of feeds in experiment II and III under which the feed cost of producing one kilogram of gain was computed was as follows:

Experiment II:

Rice bran	4.80	centavos	per	kgm.
Corn	5.00	”	”	”
Copra meal	3.80	”	”	”
Shrimp	25.00	”	”	”
Cassava roots	2.00	”	”	”

Experiment III:

Rice bran	3.70	”	”	”
Corn	4.20	”	”	”
Copra meal	2.90	”	”	”
Shrimp	12.10	”	”	”
Cassava roots	2.00	”	”	”

Ration. The feeds that made up the basic ration mixtures for all the lots in experiment I, III, and IV consisted of the following:

Rice bran	60	parts
Corn	15	”
Copra meal	15	”
Dried shrimps	10	”

One and a half per cent of the following mineral mixture was added to the above ration:

Ground charcoal	40	parts
Common table salt	40	’
Air-slaked lime	20	”

Owing to shortage of shrimps, the pigs in experiment II received a modified mixture as follows:

Rice bran	60 parts
Corn	20 "
Copra meal	16 "
Dried shrimps	4 "

The same amount and proportion of mineral mixture as used in experiment I, III, and IV was given to the pigs in experiment II.

Methods

Experiment I. The object of experiment I was to determine whether or not certain varieties of cassava are poisonous to pigs. Five varieties of cassava that are generally considered as sweet; namely, Rough Intermediate, Angular, Leyte Unknown, Casjave Singkong Manis and Kapo White were tested. The test for each of these varieties of cassava was made on one pig. Each of the pigs under test was full fed with the basic ration for the first week; from the second week on, the basic ration was gradually replaced by cassava: five per cent in the second week, ten per cent in the third week, fifteen per cent in the fourth week and so on until fifty per cent of the ration was replaced.[3] Observations were made daily with the object of discovering any symptoms of poisoning. To eliminate as much as possible the effect of parasitic infestation, fecal examination of the individual pigs was made before and toward the last period of the experiment. No animal was found infested with parasites.

Experiment II. The object of experiment II was to determine the effect on the growth of pigs of feeding varying amounts of cassava. In this experiment there were five lots with five pigs each. Lot I received only the basic ration mixture used in all the lots and served as the control lot; lot II received 95 per cent basic ration plus 5 per cent cassava; lot III, 90 per cent of the ration mixture plus 10 per cent cassava; lot IV, 85 per cent plus 15 per cent cassava; lot V, 80 per cent ration plus 20 per cent cassava. The variety used in this experiment was Kapo White as it was the one most readily available at the time and incidentally it gave the best results in experiment I.

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[3] The replacement of a part of the concentrate ration by cassava was in the proportion of one part concentrate to three parts cassava by weight in all experiments.

Experiment III. The object of experiment III was to determine whether or not certain varieties of cassava are better than others for hog feeding purposes. Five lots with five pigs each were used. Four varieties of cassava; namely, Mandioca Tapicuru, Aipin Valenca, Mandioca Itaparica, and Mandioca Basiorao were used in this experiment. The optimum amount of cassava, five per cent, as indicated by the results of experiment II, was used in this experiment: that is, every lot except the control lot received five per cent cassava.

Experiment IV. This experiment like experiment I was conducted to test the poisonous nature of cassava. The method used in experiment I was modified to obviate the possibility of developing tolerance to the poison by the pigs. Four varieties of cassava; namely, Mandioca Tapicuru, Mandioca Itaparica, Mandioca Basiorao, and Aipin Valenca were tested. The experiment consisted of six sets. In each set four pigs, one for each variety of cassava to be tested, were used. Each pig in the first set was fed 85 per cent of the basal feed plus 15 per cent of the cassava variety under trial; in the second set, 80 per cent of the basal feed plus 20 per cent of cassava; in the third set, 75 per cent of the basal feed plus 25 per cent of cassava; in the fourth set, 70 per cent of the basal feed plus 30 per cent of cassava; in the fifth set, 65 per cent of the basal feed plus 35 per cent of cassava; and in the sixth set, 60 per cent of the basal feed plus 40 per cent of cassava. The cassava in the sixth set was about the maximum amount that the pigs could ingest.

a. Preparation of the ration. A sufficient amount of basic feed was prepared to last the animals one week. A sufficient quantity of cassava roots were dug to last three days. In all the experiments, cassava was fed raw, chopped and unpeeled. Cassava roots were chopped and weighed immediately before feeding time, mixed with the concentrate ration mixture and fed to the animals.

Because the roots of cassava were fed unpeeled and also because of the difference in their HCN content, it was necessary to determine the proportion of the edible portion to the skin. It was found to be 19.2 per cent bark and 80.8 per cent edible portion, which was essentially the same as the analysis reported by Mendiola (1931). Following is the tabulated data obtained from the determination of the five samples:

NO. OF TRIALS	SAMPLE WEIGHT OF	CONSTITUENT	
		Weight of bark	Weight of meat (edible portion)
	grams	*grams*	*grams*
1	1000	150	850
2	1000	200	800
3	1000	190	810
4	1000	220	780
5	1000	200.	800
Average	1000	192	808
Percentage	—	19.2	80.8

b. Feeding and weighing. In all the experiments the pigs were fed regularly twice a day, between 5:00 a. m. and 6:00 a. m. and between 4:00 p. m. and 5:00 p. m. Initial, final and weekly weights were taken in the usual manner.

c. Care and management. Aside from the difference in the ration given, the pigs by lots were all treated in the same manner throughout the tests.

The pigs in experiment I were dry-lot fed. They occupied a pen in the hog house with yards adjoining. The pigs had no access to a wallow. Water, however, was given to them at noon after they were washed. The pigs were fed individually and were allowed all the feeds they would consume.

The pigs in Experiment II were also dry-lot fed. They occupied a paddock in the piggery of about one-sixteenth of a hectare, bare of vegetation. Acacia trees growing on one side of the inclosure furnished the pigs shelter. They occupied this paddock between feeding times. At feeding time they were driven to the hog house and fed by lots. Water was given to them at noon.

The pigs in Experiment III were also dry-lot fed. They were closely confined in pens but they had access all the time to a small adjoining yard bare of vegetation. They were bathed and watered at noon.

The pigs in Experiment IV were also dry-lot fed. They occupied one of the pig pens with a yard adjoining. They were treated in much the same manner as the pigs in experiment III except that they were fed separately and individually.

Symptoms of poisoning. As a basis for determining the poisonous nature of cassava, observations were made on the pigs showing any of the symptoms usually attributed to poisoning. According to Hutyra and Marek (1920), one or more of the following symptoms may indicate poisoning: salivation, excitement, vomiting, diarrhea with or without streaks of blood in the excreta, abdominal pain, trembling or twitching of muscles, and convulsions. These may be followed by weakness, coma, stupor, collapse, and death. The act of vomiting is a manifestation of stomach irritation, congestion or inflammation (gastritis); excessive looseness of the bowels is a symptom of congestion or inflammation of the intestines (enteritis). The presence of blood streaks may indicate rupture of blood vessels or actual cauterization of tissues by the poison.

By way of illustration of the local manifestation of cassava poisoning three cases observed by Dr. Mariano Mondoñedo of the Department of Animal Husbandry involving animals not connected with these experiments are here presented:

Case No. 1: Unpeeled boiled cassava roots intended for human consumption were found to be bitter in taste so were given to a pig. Within a few hours the pig was found in a state of collapse but with muscles still twitching. Apparently the pig had taken a large dose of the poison (HCN). The animal was too weak to vomit or defecate. It could only urinate.

Case No. 2: Boiled roots of cassava which were intended for human consumption when found to be bitter in taste were given to a pig. The pig when noticed was already beyond recovery; it was in a state of spasmodic convulsion, with twitching of the muscles. It was reported that the excreta of the pig was streaked with fresh blood.

Case No. 3: A herd of gilts was turned overnight into an old cassava lot. Apparently one of the gilts found an old root, dug it out and ate it. This gilt was found dead in the pasture the next morning. Upon post mortem examination the stomach was found to be almost full of a mixture of grain, grasses, and cassava roots. The stomach and small intestines showed general congestion, a large part of the fundus region was inflamed and hemorrhagic, and the contents streaked with blood.

RESULTS

Experiment I. Feeding pigs with cassava of the varieties Leyte Unknown, Angular, Casjave Singkong Manis, Kapo White, and

Rough Intermediate to the extent of from 0.77 kgm. to 1.07 kgm. actual weight daily per pig or from 3.3 per cent to 3.7 per cent per 100 kgm. live weight daily produced no perceptible symptoms of poisoning.

Experiment II. The replacement of from five to fifteen per cent of a full ration for pigs in dry-lot by raw and unpeeled cassava roots in the proportion of one part concentrate to three parts cassava proved as efficient, if not more so, as feeding concentrate alone. The substitution of twenty per cent of the grains appeared to decrease the rate of gain and increased the amount of feed for a given unit of gain.

Experiment III. Statistically, no significant differences were obtained by feeding pigs a full ration of concentrates (lot 1), and replacing five per cent of the concentrate ration by cassava (Mandioca Tapicuru for lot II, Aipin Valenca for lot III, Mandioca Itaparica for lot IV, and Mandioca Basiorao for lot V). There was, however, a perceptible consistent superiority shown by Aipin Valenca followed closely by Mandioca Basiorao.

Experiment IV. Feeding pigs with the varieties Mandioca Tapicuru, Aipin Valenca, Mandioca Itaparica, and Mandioca Basiorao to the extent of from 0.98 kgm. to 1.00 kgm. actual weight daily per pig or from 1.93 per cent to 1.98 per cent per 100 kgm. live weight daily produced no perceptible symptoms of poisoning.

DISCUSSION OF RESULTS

Experiment I. In experiment I five varieties of cassava; namely, Kapo White, Angular, Casjave Singkong Manis, Leyte Unknown, and Rough Intermediate were tested. Throughout the course of the feeding trial of 70 days there was no perceptible symptom of poisoning noted. Each of the pigs subjected to the test behaved normally and remained apparently healthy. The pigs during the tenth week of the feeding trial were fed cassava at the rate of from 3.3 kgm. to 3.6 kgm. per 100 kgm. live weight daily and none of them showed any symptoms of poisoning. During the last week of the test, pig No. 2 was getting on the average 0.64 kgm. cassava of the Angular variety daily or at the rate of 3.5 per cent of its live weight. According to analysis, this amount of cassava contains 0.01 gram of HCN. Pig No. 3 was getting 1.00 kgm. cassava of the Kapo White variety daily which was 3.3 per cent of its live weight and contained 0.08 gram of HCN. Pig No. 5 was getting 1.00 kgm. cassava of the variety Casjave Singkong Manis which was 3.6 per cent of its live weight and contains about 0.10 gram of HCN. None of these pigs showed any symptoms of poisoning. The amount of HCN received by pig No. 1 and No. 4 can not be given because no analysis for their HCN content was made. The fact remained, however, that pig No. 1 receiving 0.77 kgm. cassava daily of the Rough Intermediate variety or 3.5 per cent of its live weight and pig No. 4 receiving 0.86 kgm. cassava of the Leyte Unknown variety per day or 3.7 per cent of its live weight were not poisoned.

Experiment II. Table I shows the summary of results obtained in experiment II. From this table it may be noted that lot II (5 per cent cassava on the basis of 3 parts cassava to one of concentrate), made the most rapid gain; lot III (10 per cent cassava), second; lot IV (15 per cent cassava), third; lot I (control), fourth; and lot V (20 per cent cassava), the least. The differences in gain, however, between the lots were small. Lot II made an average daily gain per pig of 0.42 kgm.; lot III, 0.42 kgm. lot IV, 0.40 kgm.; lot I, 0.38 kgm.; and lot V, 0.35 kgm. It may also be noted that from the point of view of the amount of feed required to make a kgm. gain, lot II required the least amount of feed with 5.32 kgm.; lot III with 5.38 kgm. was second; lot IV with 5.47 kgm. third; lot I with 5.62 kgm., fourth; and lot V with 6.01 kgm., fifth. The results show that lot I pigs fed exclusively with the concentrate ration were not getting the same benefits that lots III, II, and IV were getting from a portion of the concentrate ration plus roots of cassava fed to them. The pigs in lot V with 20 per cent cassava apparently were given more than was good for them, as shown by the fact that they not only made the slowest gains but they required the largest amount of feed for a given unit of gain.

With the cost of feed considered, lot IV made the greatest gain followed by lots V, III, II and I in the order named. These differences were largely due to the fact that cassava is much cheaper than the basic ration mixture—a kilogram of the concentrate mixture costs five and one half centavos while a kilogram of cassava costs two centavos.

The differences in the rate of gain made by the five lots, when statistically treated were found insignificant. It should be noted, however, that between lot V and any of the other lots the differences was marked. The replacement was on the basis of three parts cassava to one part of the concentrate mixture. Because of this fact, five per cent, ten per cent, fifteen per cent, and twenty per cent of the concentrate ration substituted should be interpreted as three times by weight of cassava. Actually, lot II pigs during the feeding trial received about 0.65 kgm.; lot III, 1.03 kgm.; lot IV, 1.40 kgm.; and lot V, 1.70 kgm. cassava for every 100 kgm. live weight.

Experiment III. The amount of the basic concentrate replaced by cassava in this experiment was five per cent as indicated by the results of experiment II. It may also be mentioned that all the lots were dry-lot fed. Lot I received full ration of the basic concentrate. The other four lots of pigs received 95 per cent full ration of the basic feed, the other 5 per cent being in the form of cassava of different varieties. Lot II was given the Mandioca Tapicuru variety; lot III, Aipin Valenca; lot IV, Mandioca Itaparica; and lot V, Mandioca Basiorao.

Table 2 summarizes the results obtained in this experiment. It may be seen that from the viewpoint of the rapidity of gain as well as the amount of feed consumed per unit of gain, lots III, V, and I gave about the best results lots II and IV, the poorest. In feed cost, of the gains made, lots III and V were the most economical, lot I the most expensive, and lots II and IV, intermediate.

When the rate of gains made by the different lots were treated statistically it was found to be insignificant. It should be noted, however, that the results obtained in lot III where Aipin Valenca was the variety used were consistently superior to those obtained from the other lots. Mendiola (1931) characterizes Aipin Valenca as not poisonous and with good flavor. Sison (1921) regards Aipin Valenca as palatable and not very fibrous. Mandioca Basiorao appears to be second best. Mendiola (1921), classifies Mandioca Basiorao as fair in palatability. According to Sison (1921), Mandioca Basiorao is very palatable. Aipin Valenca and Mandioca Basiorao are similar in fiber content. Mandioca Itaparica (lot IV) and Mandioca Tapicuru (lot II) gave about the same results in this experiment. According to Mendiola (1931), these two varieties are both non-poisonous. In flavor he pronounced Mandioca Itaparica as "good" and Mandioca Tapicuru as "fair". The experiment, in general, shows that it is practical and economical to replace a part of the grain feed (five per cent full ration) with any of the varieties of cassava tested in this experiment for pigs under dry lot feeding.

Experiment IV. The varieties tested for their poisonous effects on pigs were Aipin Valenca, Mandioca Itaparica, Mandioca Basiorao, and Mandioca Tapicuru. None of the pigs showed any symptoms of poisoning resulting from feeding on these varieties. Even with the sixth set of this experiment where the pigs were getting the maximum amount of cassava no symptoms of poisoning could be noted. According to analysis, pig No. 1 was getting about 0.10 gram of HCN daily for a week of the variety Mandioca Tapicuru; pig No. 2, about 0.08 gram of HCN daily of the variety Aipin Valenca; pig No. 3, 0.08 gram of HCN daily of the variety Mandioca Itaparica; pig No. 4, 0.12 gram of HCN of the variety Mandioca Basiorao.

SUMMARY OF RESULTS

1. Experiments I and IV demonstrated that the nine varieties of cassava under test; namely, Rough Intermediate, Kapo White. Leyte Unknown, Angular, Casjave Singkong Manis, Mandioca Itaparica, Mandioca Tapicuru, Aipin Valenca, and Mandioca Basiorao, did not produce fatal or injurious effects on the pigs fed with them.

2. Experiment II showed that from the point of view of rate of gain and feed consumed for a given unit of gain, the replacement of from five to fifteen per cent of the basic concentrate ration by cassava in the proportion of three parts cassava roots to one part of the concentrate, proved to be the most practical and economical. The replacement of twenty per cent by cassava as shown by lot V markedly reduced the rate of gain and increased the amount of feed required for a given unit of gain.

3. If the rate of gain is used as a measure for the comparative efficiency of the varieties of cassava studied and the results are subjected to statistical treatment, there is no significant difference between Mandioca Tapicuru, Mandioca Itaparica, Mandioca Basiorao, and Aipin Valenca. Aipin Valenca consistently gave the best results with Mandioca Basiorao second. The results in this experiment corroborate the results in experiment II in that the replacement of a part (five per cent) of concentrate ration by cassava roots is practical and economical particularly in a dry-lot system of feeding.

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TABLE 1

Summary of results in Experiment II

ITEMS	LOT I (Control)	LOT II (5 per cent cassava)	LOT III (10 per cent cassava)	LOT IV (15 per cent cassava)	LOT V (20 per cent cassava)
Average initial weight	40.36 kgm.	40.20 kgm.	50.24 kgm.	40.08 kgm.	40.20 kgm.
Average final weight	67.24 ”	69.76 ”	69.24 ”	68.12 ”	64.52 ”
Average daily gain per pig .	0.38 ”	0.42 ”	0.4 ”	0.40 ”	0.35 ”
Percentage of ration to live weight	2.82	2.84	2.88	2.91	2.79
Feeds consumed per kgm. gain	5.62 kgm.	5.32 kgm.	5.38 kgm.	5.47 kgm.	6.01 kgm.
Feed cost per kgm. gain	₱0.36	₱0.27	₱0.25	₱0.23	₱0.24

TABLE 2

Summary of results in Experiment III

ITEMS	LOT I (Control)	LOT II (5 per cent Mandioca Tapicuru)	LOT III (5 per cent Aipin Valenca)	LOT IV (5 per cent Mandioca Itaparica)	LOT V (5 per cent Mandioca Basiorao)
Average initial weight	7.12 kgm.	7.16 kgm.	7.20 kgm.	7.16 kgm.	7.08 kgm.
Average final weight	25.28 ”	22.68 ”	26.04 ”	23.36 ”	25.80 ”
Average daily gain per pig .	0.26 ”	0.22 ”	0.27 ”	0.23 ”	0.27 ”
Percentage of ration to live weight	3.14	3.04	2.96	2.96	2.91
Feeds consumed per kgm. gain	2.80 kgm.	2.95 kgm.	2.62 kgm.	2.79 kgm.	2.56 kgm.
Feed cost per kgm. gain	₱0.12	₱0.12	₱0.11	₱0.12	₱0.11

ABSTRACT[1]

An acclimatization test of nine newly introduced varieties of soybean in the College of Agriculture. FAUSTO H. FERMIN. (*Thesis presented for graduation, 1935, with the degree of Bachelor of Agriculture from the College of Agriculture, No. 518; Experiment Station contribution No. 1161*).—The author worked on three objects: (*a*) To determine the adaptability of nine newly introduced varieties of soybean in the College of Agriculture; (*b*) to determine the best season for planting; and (*c*) to determine the yield and age at maturity of each variety.

The soybean seeds were obtained from the College of Agriculture, National University, Nanking, China. The varieties studied were: Yue Yin September Yellow; American Small Black; Yue Yin Goat's Eye; Szechwan Bar District Red; Peiping Green and Peiping Brown; Fenglein White Eyebrow; Head Green; and variety No. 19224. (Variety name not given by sender). The Ami soybean was used as a Philippine standard variety for comparison. Ten empty petroleum cans for each variety were used in pot culture, except with the Fenglein white eyebrow variety, for which only seven cans were planted.

Two wet and two dry season cultures of these varieties were grown in the field.

The author made observations on the following characters: (*a*) period of germination; (*b*) vigor and habit of growth; (*c*) period of blooming; (*d*) period of maturity; (*e*) yield of each variety; (*f*) susceptibility to pests and diseases; (*g*) number of seeds and weight per unit volume; and (*h*) weight per given number and number per given weight.

The following results were reported by the author:

1. The differences in the duration of germination of seeds of the different varieties studied were not insignificant. In the pot culture the percentages of germination were, in general, higher than the percentages of germination in the field culture. Of the nine

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[1] Abstract prepared as a part of required theme work in English 3a, College of Agriculture.

varieties studied, the Head Green and variety No. 19224 gave the highest percentages of germination in both the pot and field cultures.

2. The duration of blooming and maturity of each variety was longer in the wet season than in the dry. In the field culture the Head Green matured in from 101 to 111 days in the wet season and 78 to 91 days in the dry season; the variety No. 19224 in from 96 to 106 days in the wet season and 75 to 80 days in the dry season; the Fenglein White Eyebrow in from 92 to 99 days in the wet season and in 73 to 78 days in the dry season; the Peiping Green in from 77 to 82 days in the wet season and in 72 days in the dry season; the Szechwan Bar District Red in from 83 to 88 days in the wet season and 72 to 75 days in the dry season; the Yue Yin September Yellow in from 91 to 97 days in the wet season and 71 to 78 days in the dry season; the American Small Black in from 81 to 85 days in the wet season and 72 to 75 days in the dry season; the Ami in from 122 to 136 days in the wet season and 92 to 102 days in the dry season.

In the pot culture it took the Head Green 121 days to mature; the American Small Black, 125 days; variety No. 19224, 126 days; Szechwan Bar District Red and Peiping Brown, 129 days; Yue Yin September Yellow and Fenglein White Eyebrow, 131 days; and the Ami variety, 148 days.

3. Ami variety, No. 19224 and Head Green gave the highest average measurement in height, and varieties Ami, No. 19224 and Yue Yin September Yellow gave the widest spread.

4. In the second wet season harvest, the yield of seed of the highest yielders among the introduced varieties was higher than the yield of the same varieties in the first wet season harvest. In the second dry season harvest, the yield of these highest yielders of seed was higher than in the first dry season harvest, with the exception of Fenglein White Eyebrow variety, which was higher than the Head Green in the second dry season harvest.

5. Of the nine newly introduced varieties studied one was not able to survive and only three out of the eight varieties which seemed to thrive under Los Baños conditions are promising.

6. In yield of both seed and straw the varieties that proved worth while growing are the Head Green, variety No. 19224 and Yue Yin September Yellow. The production in seed of each of these three varieties was from about one-third to almost one-half of

the yield of Ami, the standard variety. In the future, variety No. 19224 may equal, if not surpass, the Ami in yield.

7. The average number of seeds and the weight per one-half liter of the different varieties were: variety No. 19224, 3,636 seeds weighing 353.465 grams; Head Green, 5010 seeds weighing 359.235 grams; the American Small Black, 5822 seeds weighing 370.10 grams; Yue Yin September Yellow, 1,334 seeds weighing 361.765 grams; and the Ami variety, 3858 seeds weighing 368.970 grams.

8. The average weight per hundred seeds was: American Small Black, 6.369 grams; Head Green, 7.170 grams; No. 19224, 9.712 grams; Yue Yin September Yellow, 27.118 grams, and the Ami variety, 9.563 grams.

9. The number of seeds per 100 grams was: Yue Yin September Yellow, 368; variety No. 19224, 1028 Head Green, 1394; American Small Black, 1573 and the Ami variety, 1045.

10. Most of the introduced varieties were attacked by *Agromyza phaseoli* and *Phaneroptera furcifera*. The attack on the Ami variety was very little. The only disease found on the introduced varieties was the bacterial postule caused by *Bacterium phaseoli* variety Sojense.

11. The wet season was found to be the best season for planting.

—Abstract by Aquilino V. Platon

COLLEGE AND ALUMNI NOTES

A series of educational broadcasts was given by members of the faculty of the College over Radio Manila every Saturday evening at 7:15 during December, 1936, and January, 1937.

* * *

Dean and Mrs. B. M. Gonzalez were hosts to the faculty and employees of the College on New Year's Eve at a merry-making party in the Molawin Hall. To be sure that 1937 was properly ushered in, the New Year was greeted twice: first, at midnight, Philippine daylight saving time, and second, at midnight, 120th east meridian time.

* * *

The Committee on Music and Drama was sponsor to a concert given by the College Symphony Orchestra on Friday evening, December 11, in which several guest artists from Manila participated.

* * *

Delightful Christmas programs were held by the Rural High School students on December 16 and by the Maquiling School for Faculty Children on December 18.

* * *

In C. W. Wardlaw's *Diseases of the Banana and of the Manila Hemp Plant* (London: MacMillan and Co., 1935), the text and illustrations of chapter 17 (pp. 364-376), on virus disease of abacá, are based almost entirely on the work of Dr. G. O. Ocfemia and his students at the College of Agriculture. Eleven of their published papers are cited in the book.

* * *

An illustrated lecture on "Russians in Manchuria" was given by Mr. Howard L. Huag, national general secretary, Y. M. C. A., at the College auditorium on December 17. The lecture was under the auspices of the Los Baños Y. M. C. A.

* * *

Christmas vacation for the College lasted from December 20, 1936, to January 10, 1937. While all the classes were suspended, many of the students and most of the faculty members had to remain on the campus, although the latter were on teachers' leave, to keep experimental work and other continuous activities of the institution going.

After the day's work. (J. B. Banzon photo)

THE REVISED GENERAL AND THE NEW ASSOCIATE CURRICULA OF THE COLLEGE OF AGRICULTURE

A new revision of the general curriculum of the College of Agriculture was recently approved to become effective beginning the academic year 1937-1938. The first year of the revised curriculum will be available in June, 1937; thereafter, an additional year will be organized progressively at each of the next three succeeding academic years.

The present revision of the general course constitutes the eighth since the foundation of the College in June, 1909. The average interval between revisions, therefore, is about four years. These frequent changes have had to be made, in an effort on the part of the institution to keep itself in constant gear with current developments in tropical agricultural science and in order that it might more effectively meet the increasing demands of a rapidly growing country.

By way of providing a suitable perspective, a summary is given below, in chronological order, of the different stages in the evolution of the curriculum of the College.

1909. June 14. First classes held. Only the six-year B.Agr. curriculum (based on intermediate graduation) available.

1911. First revision of the B.Agr. curriculum. The four-year B.S.Agr. curriculum (based on secondary-school graduation) instituted.

1915. Second revision of the B.Agr. curriculum.

1917. Third revision of the B.Agr. curriculum.

1918. Fourth revision of the B.Agr. curriculum and first revision of the B.S.Agr. curriculum.

1921. Fifth revision of the B.Agr. curriculum and second revision of the B.S.Agr. curriculum. Institution of the following additional curricula: (*a*) Four-year B.S.Agr. Animal Husbandry; (*b*) six-year B.Agr. Animal Husbandry; (*c*) five-year B.S.Agr., with certificate in sugar technology; (*d*) eight-year B.Agr., with certificate in sugar technology.

1923. Sixth revision of the B.Agr. curriculum; third revision of the B.S.Agr. curriculum; and first revision of the four specialized curricula established in 1921, wherein the eight-year B.Agr., with certificate in sugar technology, was abolished. A supplementary curriculum was instituted, whereby a B.Agr. graduate could make up his various deficiencies through one extra year of additional work, in order to entitle him to the degree of B.S.Agr.

1925. Retirement of the five-year B.S.Agr. curriculum, with certificate in sugar technology, and institution of a five-year sugar-technology curriculum, leading to the degree of B.S.S.T.

1926. Institution of the combined Animal Husbandry and Veterinary Science curriculum (six years, based on secondary-school graduation).

1929. Retirement of the six-year B.Agr. curriculum. Consolidation of all the specialized four-year curricula with the general B.S.Agr. curriculum. First revision of the B.S.S.T. curriculum. Institution of curriculum leading to Certificate in Agricultural Education.

1932. First revision of curriculum leading to Certificate in Agricultural Education.

1935. Abolition of the combined Animal Husbandry and Veterinary Science curriculum. Second revision of the B.S.S.T. curriculum.

1937. Fourth revision of the B.S.Agr. curriculum and third revision of the B.S.S.T. curriculum. Institution of the two-year curriculum leading to the title of Associate in Agriculture.

THE COLLEGE OF AGRICULTURE GENERAL COURSE (LONG COURSE)

The College of Agriculture General Course leads to the degree of Bachelor of Science in Agriculture and consists of a four-year schedule of collegiate work. The course is open to students who have completed the following subjects in a recognized secondary school:

Subjects	*H. S. Units*	*Subjects*	*H. S. Units*
Algebra	1½	Physics	1
Biology, botany or zoölogy	1	Plane geometry	1
Electives	4½	English	5
History	2		
		Total	16

First Year

1st Semester	*Units*	*2nd Semester*	*Units*
Animal Husbandry 1	2	Animal Husbandry 1	2
Agricultural Economics 1	2	Agricultural Economics 1	2
Agronomy 1	3	Agronomy 1	3
Agricultural Chemistry 1a	5	Agricultural Chemistry 1b	5
Mathematics 1	3	Soils 1	3
Agricultural Botany 1	5	Agricultural Botany 1	5
Military Science 1	1½	Military Science 1	1½
Physical Education 1 and 2	2	Physical Education 1 and 2	2
	23½		23½

SECOND YEAR

	Units		*Units*
Animal Husbandry 2	2	Animal Husbandry 2	2
Agronomy 2	5	Agronomy 2	5
Zoölogy 1	5	Agricultural Chemistry 2	5
English 1a	3	English 1b	3
Plant Pathology 1	5	Physics 1	5
Military Science 2	1½	Military Science 2	1½
Physical Education 3	1	Physical Education 3	1
	22½		22½

THIRD YEAR

	Units		*Units*
Agricultural Engineering 1a	3	Agricultural Engineering 1b	3
Agricultural Economics 2	3	Agricultural Economics 2	3
Agricultural Botany 2 or Agricultural Chemistry 15	5	Agricultural Education 1	3
Entomology 1	5	Major	7
Agricultural Engineering 3	3	Prescribed Elective *	3
Physical Education 4	1	Physical Education 4	1
	20		20

FOURTH YEAR

	Units		*Units*
English 10	3	Prescribed Elective *	5
Free Elective	6	Free Elective	6
Major	10	Major	8
	19		19

For purposes of comparison, the respective loads carried in the last previous, or old, curriculum and the new one are tabulated below. The most important difference is that the new curriculum is lighter by 10 units, to say nothing of the entire omission therefrom of the required 33 unit-hours (or 99 actual hours) of farm experience A, B (or H), and C, (summer practical work in agronomy, blacksmithing [or home economics for young women], and carpentry). The academic loads that suffered the greatest reduction in the new curriculum were the prescribed elective and major, the intention being to attain greater flexibility in the training of the young undergraduate and, likewise, to obviate the evils of overspecialization at so early a stage in the student's career. As an added means of insuring a broader preparation to meet the problems in an agricultural community, a new course has been included, namely, Agricultural

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* To be prescribed by the Head of the Department under which the student is majoring.

Education 1 (rural sociology). The tabulation does not list the courses in military training and physical education, both of which continue, as in the past, to be prescribed in the curricula of all colleges in the University of the Philippines.

A comparison of the new and the old curricula of the College of Agriculture

COURSES	OLD	NEW	DIFFERENCE
	units	*units*	*units*
Agricultural education	0	3	+ 3
Agronomy	14	16	+ 2
Animal husbandry	7	8	+ 1
Botany	10 (or 15)	10 (or 15)	
Chemistry	15 (or 20)	15 (or 20)	
Economics	10	10	
Elective, free	10	12	+ 2
Elective, prescribed	16	8	— 8
Engineering	9	9	
English	10	9	— 1
Entomology	5	5	
Major	32	25	— 7
Mathematics	3	3	
Plant pathology	5	5	
Physics	5	5	
Soils	5	3	— 2
Zoölogy	5	5	
Total	166	156	—10
Farm experience A, B (or H), C	33 unit-hrs.	0	—33 unit-hrs.

In addition to the foregoing four-year general curriculum, which leads to the degree of bachelor of science in agriculture, a new two-year curriculum (middle course) has been instituted, likewise to become effective in June, 1937. The middle course leads to the title (not degree) of associate in agriculture. The first year is identical in every respect with that of the general course. The object of the common first year is, of course, to give the student ample time before final commitment in the choice of a career. He has one year to look around, measure his individual aptitude, and consult his personal inclination, before he finally makes up his mind. The two-year course is designed primarily for those who wish merely to acquire the necessary practical knowledge, particularly in agronomy and animal husbandry, that would help him run a farm. The second year is so planned that the student is given an adequate utilitarian training. Appropriate courses have been organized especially for this new curriculum.

THE COLLEGE OF AGRICULTURE TWO-YEAR COURSE (MIDDLE COURSE)

The College of Agriculture two-year course leads to the title of Associate in Agriculture. The entrance requirements to this course are the same as those of the long course.

FIRST YEAR

1st Semester	*Units*	*2nd Semester*	*Units*
Animal Husbandry 1	2	Animal Husbandry 1	2
Agricultural Economics 1	2	Agricultural Economics 1	2
Agronomy 1	3	Agronomy 1	3
Agricultural Chemistry 1a	5	Agricultural Chemistry 1b	5
Mathematics 1	3	Soils 1	3
Agricultural Botany 1	5	Agricultural Botany 1	5
Military Science 1	1½	Military Science 1	1½
Physical Education 1 and 2	2	Physical Education 1 and 2	2
	23½		23½

SECOND YEAR

	Units		*Units*
Animal Husbandry 2 *	2	Animal Husbandry 2 *	2
Agronomy 2	5	Agronomy 2	5
Animal Husbandry Elective	5	Animal Husbandry Elective	5
Agronomy Elective	5	Agronomy Elective	5
Free Elective	3	Free Elective	3
Military Science 2	1½	Military Science 2	1½
Physical Education 3	1	Physical Education 3	1
	22½		22½

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* Students desiring to give emphasis to animal husbandry in their work should take Animal Husbandry 3 and 7, in lieu of Animal Husbandry 2.

A NOTE ON HAM MAKING WITHOUT REFRIGERATION [1]

By Miguel Manresa
Of the Department of Animal Husbandry

WITH THREE TEXT FIGURES

Since the publication hardly five weeks ago of newspaper articles on ham making under ordinary room temperature, that is, without refrigeration [2, 3, 4] numerous inquiries regarding the method have been received. It is with the object of furnishing the desired information that this note was prepared.

The manufacture of hams with the aid of low temperature is as old as civilization. The most popular hams consumed in the Philippines, namely, the Chinese hams, are cured in northern China during the winter, presumably under natural refrigeration, as we are told that there are no large ham factories in that region of China. Under carefully controlled conditions the benefits of natural refrigeration can be duplicated and even improved by artificial means; but in the tropics, such as in the Philippines, the problem of ham manufacture has offered considerable difficulty, even to capitalists who are in a position to put up refrigeration plants. Artificial refrigeration is very expensive, not always reliable, and certainly beyond the reach of the average man. It is not surprising, therefore, that the announcement of a method of making ham without refrigeration should arouse such general interest in the Philippines. For, if this inexpensive method can be made available in the remote barrios, it will undoubtedly help raise the economic status of the small farmer by placing in his hands an important source of income.

WORK BEGUN IN 1916

When in 1916 Professor B. M. Gonzalez started this work in this College, he realized the fact that ham making will never become a generalized Filipino home industry unless a method of manufacture that does away with refrigeration can be devised. His work on the subject and later that of Doctor Mondoñedo (1924) were successful only when small pieces weighing from one-third to one-half of a kilogram were cured.[5] Larger pieces invariably resulted in complete spoilage. All the then known methods of curing meat were tried out at periodical intervals and every time any material for the work became available. In 1932 Mondoñedo reported that pork pieces as heavy as 1.5 kilograms could be cured without refrigeration.[6] However, the method remained unsatisfactory, owing to the fact that a whole ham averages about four kilograms.

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[1] General contribution No. 549. Received for publication January 5, 1937.
[2] Manila Daily Bulletin. November 27, 28, 29, 1936.
[3] College of Agriculture Bi-Weekly Bulletin. December 1, 1936.
[4] The Graphic. December 17, 1936.

THE METHOD THAT PROVED SUCCESSFUL

When in October, 1935, young Miguel Manresa, Jr., was set to work on the project, there had been nineteen years of wild-goose chasing by his predecessors. Fortunately, he was blissfully unaware of this otherwise discouraging background. Very hopefully he went ahead, trying one method after another. Some of the methods which he used were but repetitions of the previous failures of others.

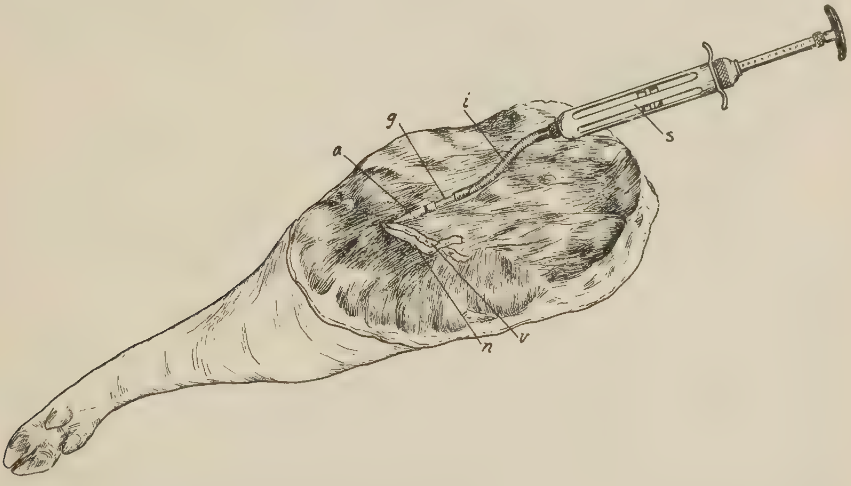

Fig. 1.—Right shoulder of a medium-sized pig showing location of brachial artery into which brine solution for curing ham is introduced by means of a syringe. *a*, artery; *g*, glass tubing connected with artery by ligatures; *i*, rubber tubing; *v*, veins; *n*, nerves.

One year of intensive work produced only putrefied hams. These varied in weight from three to six kilograms. So consistent was the smelly result that his friends, including his thesis adviser, were beginning to make some fun at his expense. Finally, a more direct introduction of the curing agents in solution into the meat by arterial injections was resorted to. This method had been previously suggested by Dean Gonzalez, but for reasons we are unable to explain it was not given a trial until all the other methods had failed.

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[5] MONDOÑEDO, MARIANO. (1924). Curing ham and bacon for home use. The Philippine Agriculturist 13: 271–276.

[6] MONDOÑEDO, MARIANO. (1932). Curing pork and making sausage for home use. The Philippine Agriculturist 21: 151–164.

Of a number of recipes used in previous experiments on ham making, the formula designated as "Mondoñedo", on the whole, had given the most promising results in curing hams under ordinary room temperature. This formula was, therefore, modified by reducing the amounts of common table salt and sugar and increasing the amount of saltpetre. The modified formula designated as "modified" was used in the experiment side by side with the Mondoñedo formula. In making the brine solution from these formulae the concentrations of the solution were made such that the Mondoñedo formula had a strength of 30 per cent, while the modified was maintained at 40 per cent throughout. The following tabulations show the details of the two formulae for curing hams:

"MONDOÑEDO" FORMULA

CURING AGENTS	AMOUNT PER 100 KGM. MEAT	AMOUNT PER KGM. MEAT	CONCENTRATION OF THE BRINE SOLUTION
	kilograms	*grams*	*per cent*
Refined table salt	25.00	250	
Sugar	5.00	50	
Saltpetre	0.30	3	
Baking soda	0.10	1	
Water	100.00 liters	1000 c.c.	30.4

"MODIFIED" FORMULA

CURING AGENTS	AMOUNT PER 100 KGM. MEAT	AMOUNT PER KGM. MEAT	CONCENTRATION OF THE BRINE SOLUTION
	kilograms	*grams*	*per cent*
Refined table salt	24.00	240	
Sugar	3.00	30	
Saltpetre	3.00	30	
Baking soda	None	None	
Water	75.00 liters	750 c.c.	40

The brine solutions were prepared by dissolving the curing agents in the required amount of water freshly taken from an artesian well. No precautions were taken as to sterilization of the water used or of the containers. These solutions were prepared in clean kerosene cans from which they were transferred into glass jars preparatory to using. The amounts of the different curing agents required in each case are determined from the foregoing formulae. Thus, suppose it is desired to cure a five-kilogram ham. Under column "amount per kgm. meat" in the table, it is seen that if the amounts in grams of common table salt, sugar, saltpetre, etc., appearing in this column be multiplied by 5, one would have sufficient brine solution with which to cure a piece of ham weighing five kilograms. After dressing the carcasses, the hams and legs were trimmed to the desired shape, taking care that the main arteries of the fore limbs, i. e., the brachial and the femoral of the hind limbs, were kept intact. Into these arteries the brine solution was introduced with the aid of a glass tubing about ten centimeters in length and of a hand syringe of 30-c.c. capacity. The injection of the brine solution was kept up until the tissues of the deep and remote parts of the legs had been suffused. Distension of the digits and the passage of the fluid from cut surfaces into very thin streams were taken as signs of proper suffusion.

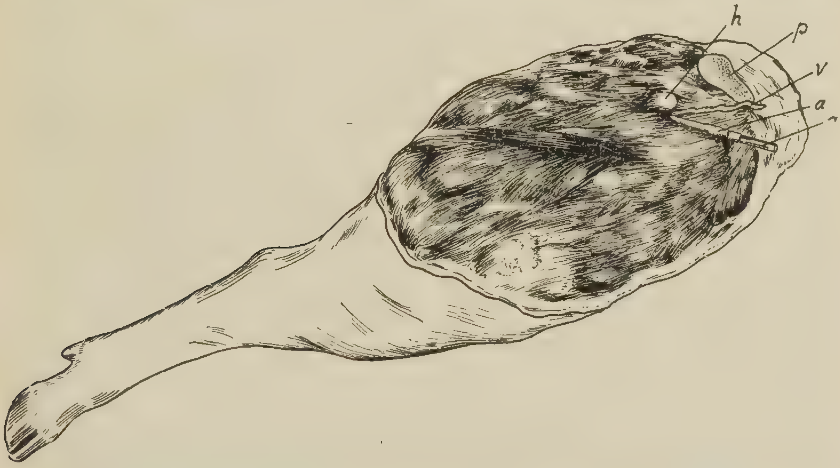

Fig. 2.—Left hind leg of a medium-sized pig showing location of femoral artery into which brine solution is introduced. Note position of artery in relation with head of femur and cut portion of aitchbone. *a*, artery; *g*, glass tubing connected with artery by ligatures; *h*, head of femur; *p*, portion of aitchbone cut; *v*, vein.

The diagrams in fig. 1 and 2 show the relative positions of the brachial artery of the fore limb and of the femoral artery of the hind limb into which the brine solution was introduced.

After this preliminary treatment, the arteries were connected to a siphon from a glass jar containing the brine. These jars were raised to a height of about two feet from the legs, and in this way the fluid was gradually allowed to flow into the tissues by gravity overnight. Fig. 3 shows the details of the process.

On the day following, brine solution was further introduced intramuscularly in various places of the meat by means of a long hypodermic needle. Then the meats were covered with the salt mixture on the outside as in dry curing. After two days of daily application of the salt mixture the hams were allowed to stand for a period of six days under a wire-screened cover. The hams were then placed in the smoke house for drying under smoke-house temperature of from 38° to 43°C. Heating of the smoke house was kept up every day until the hams attained the desired color and firmness.

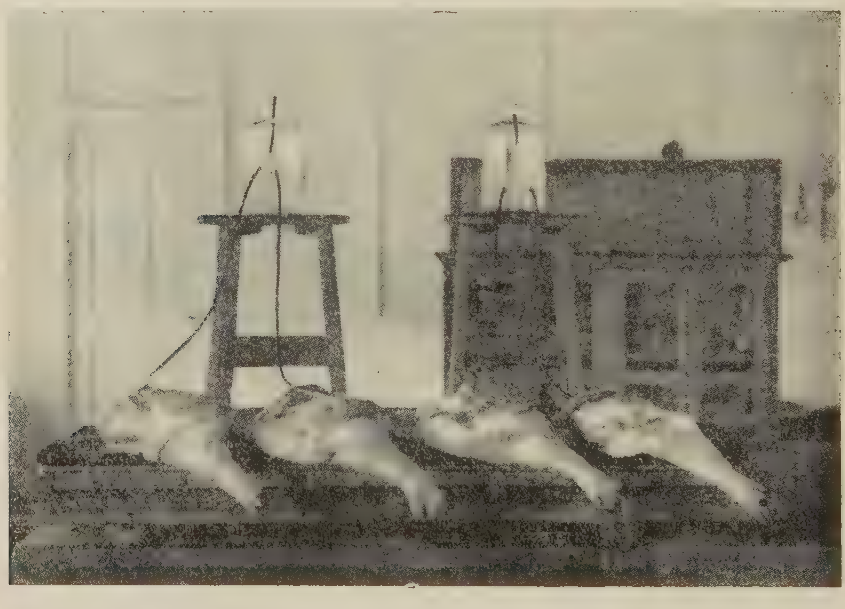

Fig. 3.—Final process in treating the ham; overnight introduction of brine solution by gravity.

Two weeks after the first batch of hams had undergone the treatment just described, it became evident that the problem of preventing spoilage was finally solved. None of the first sixteen hams treated showed any indication of putrefaction. It was deemed unsafe, however, to pronounce judgment on the success of the process without first testing the eating quality of the product. So on November 24, 1936, thirty-three days after treatment of the first four legs by this method, samples of hams were prepared for testing by members of the staff of the Department of Animal Husbandry and their wives. Five ladies and nine gentlemen of the faculty performed this test, besides a number of students. All the testers found the hams satisfactory under different methods of cooking.

FURTHER EXPERIMENTATION NEEDED

The method just described is, in fact, essentially a combination of a number of different methods of curing hams; namely, introduction of the brine solution into the arteries, first, by means of a syringe and, later, by siphon. This was followed up by intramuscular injections; and lastly, the application of the curing agents in dry form as in the dry method of curing. As it seems desirable to dispense with the intramuscular injections, further experiments were conducted. Preliminary trials indicated that a stronger concentration than 30 per cent of the brine solution is necessary to secure completely uniform pickling, if the intramuscular injections are to be eliminated.

It seems necessary to point out at this juncture that this line of attack of the problem of ham making without refrigeration has just been begun. Although the method has not, as yet, been perfected, it is safe to say that its possibilities are great. There are a number of little details that could be introduced which should not only simplify the process but also improve quality. The fundamental problem of preservation of ham without refrigeration has now been proven to be possible. Further experimentation, however, must not be stopped until a simplified process is evolved.

CHEMICAL ANALYSIS OF THE FOOD OF THE CHILDREN IN WELFAREVILLE[1]

F. O. SANTOS AND N. A. PIDLAOAN
Of the Department of Agricultural Chemistry

Welfareville is a government child-caring institution located in San Felipe Neri, Rizal, ten kilometers from the city of Manila. The food samples were obtained from the training school for boys. The boys, 466 in number, ranging from 10 to 21 years of age, were minor offenders from all over the Islands committed by the courts or by their parents or guardians. Besides studying, these boys are engaged in various vocational activities, according to their special aptitude, such as carpentry, farming, road building, making wicker furniture, etc. In general it could be said that they perform regular-muscular work.

Besides the training school for boys there are two other institutions at Welfareville: the home for the negative children of lepers and the orphanage for destitute and other needy children. The food given to the inmates of these institutions is the same as that given to those in the training school.

METHODS

The collection of samples was made by the senior author on different days from January 11 to July 15, 1934. From four to six meal-samples were taken at a time, at random, from the dining table. These samples were taken to the biochemical laboratory of the College of Agriculture for analysis. A total of seventy-eight meal-samples were taken. The refuse was carefully removed and chemical analysis was made of the edible portion. The average results of these analyses are shown in table 1.

RESULTS

The foods were rationed out to the boys—not given *ad libitum.* However, everybody was free to get any number of helpings of rice.

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[1] Experiment Station contribution, No. 1165. Read before the Third Philippine Science Convention, February 27, 1935.

Part of the expense of this investigation was defrayed by a grant by the President of the University of the Philippines from the University research fund.

Close observation showed that very few found it necessary to ask for another helping of this cereal and if one needed more, only a little amount was necessary. So it may be safely concluded that the bulk of the food given was enough to make them feel satisfied.

During regular days unpolished rice was given, but on Sundays and other holidays and occasionally even on regular days, polished rice was served. In the mornings three small loaves of bread (*pan de sal*) instead of rice were given to the boys. Also, usually at 10:00 a. m., each boy was given one small loaf of bread (*pan de sal*) with sugar. Breakfast consisted, in addition to bread, of cocoa with sweetened condensed milk, and sardines or salmon. Once a week, usually on Sundays, butter was served.

The following is a sample of menu for one week:

January 27, 1934.
    Lunch: rice, "*pacsiw*" (vinegar stew) herring (*tamban*) and toyo, banana.
    Supper: rice, fried shrimps and vinegar, *kondol* (cucurbit) sweet.

January 28, 1934.
    Lunch: rice, boiled "puchero" beef, sweet-potato and gabi with coconut milk (*guinataan*).
    Supper: rice, fried smoked herring (*tinapa*) (4 each) and fresh tomato, *macapuno* (a variety of coconut) sweet.

January 29, 1934.
    Lunch: rice, string beans with pork and shrimps, sugar sticks (*tira-tira*).
    Supper: rice, boiled (*sinigang*) beef with raddish, *kondol* sweet.

January 30, 1934.
    Lunch: rice, fried fish and vinegar, boiled Saba banana.
    Supper: rice, pickled (*adobo*) pork with *bagoong* alamang (preserved salted small shrimps), *kondol* (cucurbit) sweet.

January 31, 1934.
    Lunch: rice, boiled (*pinañgat*) herring (*siliñasi*), banana.
    Supper: rice, fried dried fish (*tuyo*) (4 each) and fresh tomatoes, squash sweet.

February 1, 1934.
    Lunch: rice, milkfish (*bañgos*) and *toyo*, banana.
    Supper: rice, boiled beef with string beans, squash sweet.

February 2, 1934.
    Lunch: rice, fried fish and fresh tomatoes, boiled Saba banana.
    Supper: rice, fried milkfish with *tahori* (fermented soy bean curd), *kondol* (cucurbit) sweet.

Note: Banana is *Latundan* unless otherwise specified.

We have assumed that the average analysis of ten breakfast meals represented the average composition of the daily breakfast food, except on Sundays. The data for lunch and supper each represented the average of from four to six meal-samples. The amounts of the food factors for breakfast, lunch and supper were added and the sum was considered as the composition of the food for one day. The average food for one day gave 17 grams minerals, 86 grams proteins, 47 grams fats, 414 grams carbohydrates and 2500 calories. These amounts were compared with other results obtained in our laboratory in table 2.

The average food of the boys compared favorably with the food of the male prisoners, when we consider that the boys did not do as much muscular work as the prisoners. The food of the boys contained a slightly greater amount of minerals, proteins and fats than the average food of Los Baños students.

The average food of the boys did not depart materially in quantity from the tentative standard for Filipinos. Our examination of these meal-samples showed that although the quality of the dishes was somewhat inferior to that prepared in restaurants, the nutritional requirement that there should be a variety of food materials used was not overlooked.

From these considerations it appeared that the children in Welfareville were not underfed.

ACKNOWLEDGMENT

The authors are indebted to the officials of Welfareville for coöperation extended throughout the investigation.

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TABLE 1

Chemical analysis of the food of the children in Welfareville

	MINERALS	PROTEINS	FATS	CHO	CALORIES
	grams	*grams*	*grams*	*grams*	
Monday					
Breakfast ..	4.38	27.40	5.78	200.24	987
Lunch	4.31	14.66	6.49	100.18	531
Supper	9.12	51.16	25.84	103.02	873
Total	17.81	93.22	38.11	403.44	2391
Tuesday					
Breakfast ..	4.38	27.40	5.78	200.24	987
Lunch	4.06	20.35	7.08	106.02	584
Supper	3.71	20.47	93.47	110.23	1405
Total	12.15	68.22	106.33	416.49	2976
Wednesday					
Breakfast ..	4.38	27.40	5.78	200.24	987
Lunch	4.46	21.95	12.13	90.89	576
Supper	9.75	47.15	26.75	99.82	852
Total	18.59	96.50	44.66	390.95	2415
Thursday					
Breakfast ..	4.38	27.40	5.78	200.24	987
Lunch	1.90	33.15	8.03	101.30	626
Supper	6.51	29.65	41.48	152.50	1133
Total	12.79	90.20	55.29	454.04	2746
Friday					
Breakfast ..	4.38	27.40	5.78	200.24	987
Lunch	10.41	26.31	8.84	95.23	581
Supper	2.51	21.00	3.09	102.53	535
Total	17.30	74.71	17.71	398.00	2103
Saturday					
Breakfast ..	4.38	27.40	5.78	200.24	987
Lunch	4.35	22.96	11.75	89.74	572
Supper	6.26	22.70	8.87	102.46	596
Total	14.99	73.06	26.40	392.44	2155
Sunday					
Breakfast ..	4.38	27.40	19.08	200.24	1111
Lunch	4.81	33.88	10.21	106.91	672
Supper	13.37	47.83	21.54	138.88	966
Total	22.56	109.11	50.83	446.03	2749
Average total ..	17	86	48	414	2500

TABLE 2

Food intake of other groups studied

	MINERALS	PROTEINS	FATS	CHO	CALORIES
	grams	*grams*	*grams*	*grams*	
Standard (tentative) (1928)	—	80	40	450	2500
Male prisoners (1933)	25	91	49	602	3300
Woman prisoners (1934)	17	69	23	467	2411
Los Baños students (1922)	14	78	38	506	2675
College of Agriculture students (1930) ...	—	82	—	—	—
Present study	17	86	48	414	2500

STUDIES ON COCONUT OIL: I. PYROLYSIS [1]

JULIAN BANZON
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WITH ONE TEXT FIGURE AND THREE CHARTS

One of the concerns of a nation is its supply of basic chemicals. Germany, as is well known, developed the chemistry of coal to such high and fine a degree that diversified products as drugs, dyes and explosives have become possible from coal. Lately, there has grown a tendency to study and exploit in like manner, products from crop plants, which have the advantage over coal in that they can be grown from year to year. Chemicals from corn, from oats and from soybean are now available on a commercial scale.

Coconut oil as a basic substance seems to have potentialities. It is relatively abundant. Pyrolysis or thermal decomposition has been applied to a number of substances, the results indicating possibilities along this direction.

Review of literature

Coconut oil is mostly a mixture of glycerol esters of fatty acids. Bomer (1914, 1920), cited by Jamieson (1932), has isolated and identified the following glycerol esters; caprylo-lauro-myristin, lauro-dimyristin, myristo-dilaurin palmitomyristin and stearo-dipalmitin. Quantitative results are not given. The percentage of glycerol, however, is around 14 per cent as computed from a saponification number of 251 to 264. The fatty acids, therefore, constitute a little over 86 per cent of coconut oil, distributed as follows: (Collin and Hilditch, 1926, cited by Jamieson, 1932).

Caproic acid $CH_3(CH_2)_4COOH$	traces
Caprylic acid $CH_3(CH_2)_6COOH$	7.9%
Capric acid $CH_3(CH_2)_8COOH$	7.2 "
Lauric acid $CH_3(CH_2)_{10}COOH$	48.0 "
Myristic acid $CH_3(CH_2)_{12}COOH$	17.5 "
Palmitic acid $CH_3(CH_2)_{14}COOH$	9.0 "
Stearic acid $CH_3(CH_2)_{16}COOH$	2.1 "
Oleic acid $CH_3(CH_2)_{14}(CH)_2COOH$	5.7 "
Linoleic acid $CH_3(CH_2)_{12}(CH)_4COOH$	2.6 "

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[1] Read before the Los Baños Biological Club, November 22, 1934, and the Third Philippine Science Convention, February 27, 1935.

Experiment Station contribution No. 1172.

Elsdon (1913), Allan and Moore (1925), Stockoe (1924), Taylor, and Clark (1927), all cited by Jamieson (1932), and Lewkowitsch (1909) report somewhat different percentages than the ones given above. Methyl heptyl and methyl ketone have been shown to be present by Haller and Lassieur (1910), cited by Jamiesond (1932).

While oils in general and coconut oil in particular have been the objects of thermal decomposition in many instances, the following investigations seem to be noteworthy:

Engler and his co-workers (1897-1909), in trying to trace the possible origin of petroleum, heated various oils, fish oils especially, under pressure, and obtained petroleum-like liquids.

Mailhe (1899-1923) subjected a number of oils to catalytic pyrolysis, among which were linseed, colza, palm, cottonseed and peanut oils. Copper zinc, nickel, cadmium; the oxides of titanium zinc, cadmium, manganese, magnesium, aluminum; kaolin and zinc chloride, were among the catalysts used. Hydrocarbons, gases, liquids resembling petroleum and a variety of compounds were obtained.

McAfee (1915) employed aluminum chloride in "cracking" mineral oil.

Kobayashi (1921) prepared artificial petroleum by heating soy bean, chrysalis and coconut oils to 700°C.

Masakadu (1921, 1923) obtained liquids, resembling petroleum by the dry distillation of the soaps of sardine, linseed, cottonseed, soy bean, and grape-seed oils.

Seiji (1922) obtained similar results by heating rosin with acid Japanese earth; Sato (1922) also obtained similar products by distilling calcium salts of soybean fatty acids.

Egloff and Morrell (1932) subjected cottonseed oil to standard cracking process as used in the petroleum industry and obtained paraffins, napthenes, aromatics, unsaturated hydrocarbons, gases, and coke.

Object

The main object of this study is to determine the behavior of coconut oil when subjected to simple heat treatments such as prolonged heating, distillation without and with metallic catalysts.

MATERIALS, APPARATUS, AND METHODS

The coconut oil used in this work was obtained from a local dealer and is the commercial product for general use.

The inorganic substances used as catalysts were the following:

1. Aluminum chloride, "pure", Schering-Kahlbaum
2. Barium chloride, "extra pure", E. Merck.
3. Cadmium chloride, C. P. Baker's analyzed.
4. Calcium acetate, "pure", Mallinckrodt.
5. Iron, "reduced by hydrogen", Merck and Co.
6. Iron oxide, Fe_2O_3, C. P. Baker's analyzed.
7. Sodium hydroxide, C. P. Baker's analyzed.
8. Zinc chloride, technical.

Specific gravity was determined by means of 5 and 10 ml. bottle pycnometers.

Viscosity was measured by wide-bore Ostwald viscosimeters, constructed for the purpose and carefully calibrated by the use of sucrose solutions of known viscosity. A Pastor stop-watch, graduated to one-fifth second, measured the time of flow.

A precision thermostat maintained the temperature 30.0° ± 0.1°C. in the determination of specific gravity and viscosity.

Refractive index was determined by an Abbe refractometer at room temperature, 28°-31°C.

Flash point and burning point. The sample, contained in a 25 ml. porcelain crucible was slowly heated in a sand bath by a Bunsen burner. A 360°C. thermometer recorded temperatures. Ignition of the oil vapors was obtained by a spark from two No. 18 (B and S gauge) chromel wires whose ends were just above the surface of the oil sample. A 6-volt battery and a Ford coil furnished the high tension current for the ignition. Duplicate burning points agreed to 3°C. and often better.

Acidity was determined by titration with 0.1 N or 0.25 N KOH, depending upon the acidity. One ml. of the sample was measured by a pipette and rinsed twice with C.P. benzene. Three drops of 10 per cent phenolphthalein indicator and 10 ml. of 95 per cent alcohol were added and then titrated. The rinsing of the pipette with benzene eliminated errors of unequal drainage which was due to the high viscosity of some samples. The pipette was recalibrated to contain exactly one ml.

Unsaponifiable matter. Current methods were found unsuitable. They either lack speed, use large quantities of sample, or have no provision for separating the unsaponifiable matter for further examination. They are based on saponification by alcoholic KOH and subsequent titration. The samples obtained in this work contained so much aldehyde that the alcoholic KOH became dark, and the end point was difficult to ascertain with the use of indicators.

The method developed for this work is based on saponification by KOH, and, instead of titrating, the unsaponifiable matter is separated by the addition of water and by centrifuging it afterward. The procedure is as follows: An automatic pipette is made to deliver 5 ml. of 1.5 N alcoholic KOH into a small-stemmed Babcock-test bottle. One ml. of the sample is pipetted in. An air condenser is attached to the bottle and the mixture heated on a water bath for 10 minutes at 80°–90°C. This heating is omitted for samples boiling below 100°C. About 5 ml. of warm water (50°C.) is added without shaking and the contents are allowed to stand for a minute or two. This avoids formation of emulsion. More water is added until it stands 2 cm. from the neck and the bottle is centrifuged for 30 seconds. Sufficient water is added to make the unsaponifiable matter float to the graduated portion of the neck and again centrifuged for 30 seconds. The volume is read off: One ml. of the oil was found to occupy on the average 5.3 divisions, or one division = 0.189 ml. Since the sample taken for analysis is 1 ml., therefore the per cent unsaponifiable matter = reading × 0.189 × 100.

With this method, no measurable amount of unsaponifiable matter was found in coconut oil. Triplicate tests on kerosene and on toluol gave 99.5 per cent and 96.3 per cent recovery, respectively. In over a hundred determinations, using the oil samples, duplicates never varied more than 0.2 division and in a large number of cases variation was only 0.1 division which is the limit of precision of the Babcock test bottle.

EXPERIMENTAL

The effect of distillation on coconut oil

Procedure: Fifty ml. of coconut oil were placed in a 125 ml. distilling flask provided with a 360°C nitrogen filled thermometer and an 18-inch water-cooled condenser. Heat from a Bunsen burner was applied at such a rate that distillation commenced within 5 to 7 minutes and the distillation rate was maintained at 2 drops/second. The distillate was fractioned into 5, 5, 10, 10, and 10 ml. These correspond to 0-10, 10-20, 20-40, 40-60 and 60-80 per cent by volume.

The process was not carried beyond the 80 per cent fraction. Temperatures were recorded at the end of every 5 ml. collected. The acidity and unsaponifiable matter of the distillates were determined. The process was repeated and the fatty acids were used for comparison.

Results: The first three fractions obtained in the distillation of coconut oil were very slightly yellow, almost colorless; the last two were yellow, the last one was more so. All had the very strong odor of acrolein; so much of this aldehyde was formed that the process was possible only when carried out in the fume hood. The residue left in the flask on cooling was dark-brown and semi-solid. When the process was repeated with the fatty acids, the distillates were all water-white, except the last fraction, which was yellowish. No aldehyde odor was obtained. The residue was also brown and semi-solid.

Table 1 shows the results obtained by distilling coconut oil. Coconut oil distilled between 267° and 310°C. with an average boiling point of 300°C. Acids were formed in the process of distillation, the amount decreased as distillation proceeded. A high percentage of unsaponifiable matter was formed which increased as distillation continued. This unsaponifiable matter was a yellowish liquid in the 0-10 and 20-40 per cent fractions and semi-solid in the other higher fractions. This solid was a waxy-white substance insoluble in water and sparingly so in cold 95 per cent ethanol, but very soluble in ether, acetone and other solvents. It was unaffected by cold concentrated HCl or HNO_3 but dissolved in concentrated H_3SO_4. It failed to react with KOH even in 3N alcoholic solution at boiling temperature for three hours.

It was suspected that the first products of the decomposition of coconut oil were the fatty acids which in turn might be the origin of the unsaponifiable matter. For this reason, pure fatty acids were prepared from the same coconut oil (by liberating the acids from the Na-soaps by H_2SO_4). The product obtained was similarly distilled. The temperatures of distillation as given in table 1 come out to be almost identical, thus precluding any one-sided effect of temperature on the results. No detectable unsaponifiable matter was found up to the 40-60 per cent fraction while the 60-80 per cent fraction gave 17.5 per cent unsaponifiable matter or only slightly over one-half the value for the corresponding fraction from the oil. The unsaponifiable matter, therefore, originated in the thermal alteration of the coconut oil glycerides and not from the free fatty acids. It would seem, then, that the oil is a more promising starting point for thermal decomposition than are the acids.

The effect of prolonged heating on coconut oil

Procedure: Three hundred ml. of coconut oil were placed in an 800-ml. Kjeldahl flask provided with a cork stopper carrying a four-foot air-cooled reflux condenser, a sampling tube and a temperature indicator as shown in figure 1A. Boiling was made to take place within 5-7 minutes and maintained for ten continuous hours; allowed to cool overnight and resumed the next morning for another ten hours. Twenty ml. samples were withdrawn with 1/4, 1/2, 1, 2, 5, 10, 15 and 20 hours from the start by means of suction applied at the sampling tube; without interrupting the boiling process. The samples were collected in test tubes, allowed to cool and examined for acidity, unsaponifiable matter, specific gravity, and viscosity.

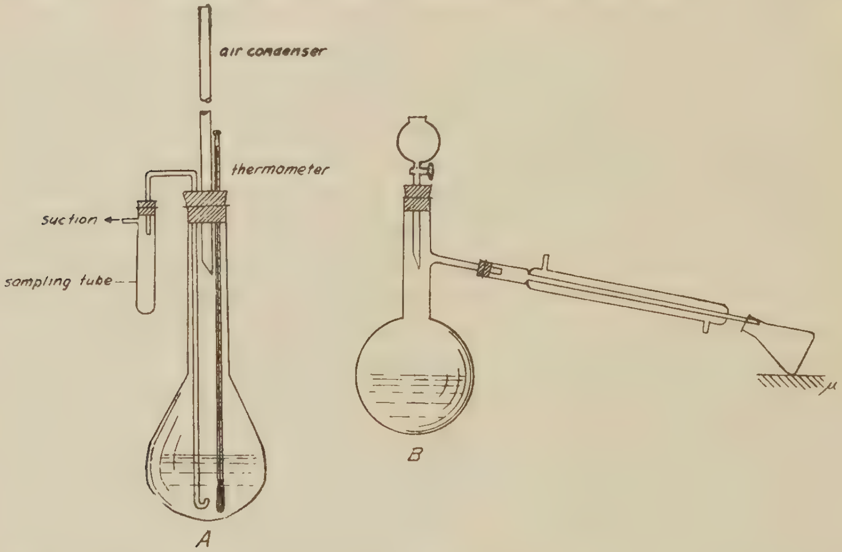

Fig. 1.—*A*. Apparatus used in the study of the effect on coconut oil of prolonged boiling.
B. Apparatus used in the pyrolysis of coconut oil.

Results: The samples of heated coconut oil collected had a progressively deepening color, from a light amber to a deep dark-brown as the heating time increased. The odor of acrolein was very strong in the samples that received shorter heating and became almost imperceptible as heating was prolonged. Samples collected within two hours heating time were liquid; after 5 hours, some solid material crystallized out on cooling; those collected after 10, 15 and 20 hours were semi-solid on cooling. The solid portion was similar in properties to the solids obtained in the distillation of coconut oil, but in larger proportions.

Table 2 and charts 1 and 2 show the behavior of coconut oil on prolonged boiling. The temperatures of sampling which is the boiling point of the liquid at the time a sample for examination was withdrawn decreased progressively as heating time was prolonged. This indicated that as coconut oil was heated, decomposition products were formed which had a lower average boiling point than coconut oil itself.

The viscosity and specific gravity fell down rapidly within five hours heating, the specific gravity continued to decrease on further heating.

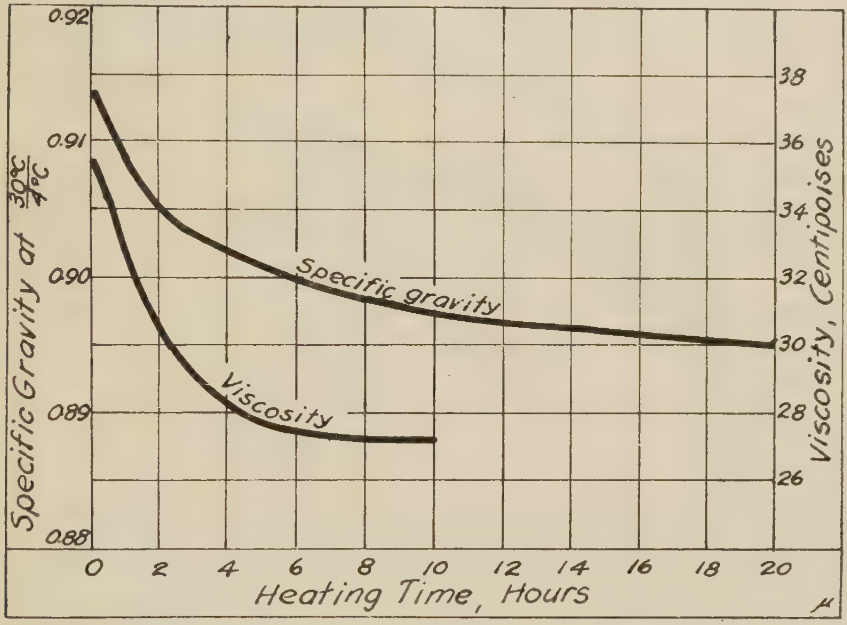

Chart 1.—Effect of prolonged boiling on the specific gravity and viscosity of coconut oil.

That prolonged boiling affected coconut oil was shown by the increase in acidity and the formation of large amounts of unsaponifiable matter (chart 2). Again as in the distillation of coconut oil, the formation of unsaponifiable matter could not be due to high temperature. The length of time of heating seemed to be the important factor.

The unsaponifiable matter obtained by boiling coconut oil was mainly solid and had the same properties as that obtained by distillation.

The effect of metallic substances on the thermal decomposition of coconut oil

Procedure: One hundred ml. of coconut oil were placed in a 125 ml. distilling flask fitted with a water-cooled condenser. Five grams of the catalytic material was added and the mixture heated such that the distillation rate was kept at about a drop every two seconds. After about one half of the original charge of oil had distilled over, an equal volume of fresh oil was added to the flask and the distillation resumed. This was repeated until 250 ml. of distillate was collected. Controls were run without a catalyst. The product thus obtained was examined for acidity and unsaponifiable matter. Its specific gravity, viscosity, refractive index, flash point, and burning point were determined. The distillation range was determined on a 50 ml. sample; the 0-10, 10-20, 20-40, 40-60 and 60-80 per cent fractions were separately collected and examined for acidity and unsaponifiable matter.

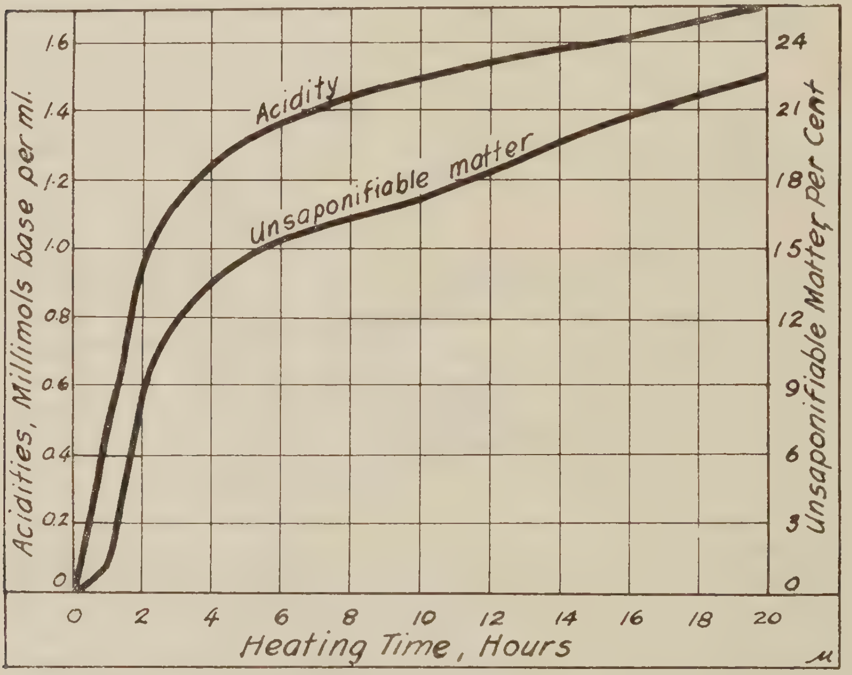

Chart 2.—Changes in acidity and unsaponifiable matter of coconut oil upon prolonged boiling.

Results: All the distillates obtained in this experiments were very mobile, of a peculiar odor and had varied colors. When NaOH, $BaCl_2$, $CdCl_2$, and $CaAc_2$ were employed, the distillates were of an amber color. $ZnCl_2$, $AlCl_3$ and $CaCl_2$ gave rise to dark-colored products. One distillate from $AlCl_3$ (sample Al-4) had strong blue fluorescence which gradually disappeared after standing for five months. Sample NaOH-4 had a strong permanent greenish fluorescence. Distillates with Fe_2O_3 or Fe as catalyst, were greenish but changed to yellowish on standing. A small quantity, one to three per cent by volume of the total distillate, was always present as a lower aqueous layer. Distillates were encountered that set solid on cooling. The catalyst and method of production of these solids will be described in a separate paper.

Some physical and chemical properties of the distillates obtained when metallic substances were employed are given in table 3. Data for coconut oil, and the fatty acids (from coconut oil) are included for comparison. Results show that when coconut oil was heated with or without metallic catalysts, the following changes took place.

1. A lowering in specific gravity and refractive index.
2. A very large decrease, over ten times, in viscosity, resulting in liquids of water-like fluidity.
3. A very large lowering in burning point, from 250°C. to temperatures below 100°C.
4. Formation of acids.
5. Formation of unsaponifiable matter, which is mostly liquid.

As to specific gravity, viscosity, refractive index and burning point, there was not much difference between the control and those in which $ZnCl_2$, $CaCl_2$, $CdCl_2$, $BaCl_2$, and $CaAc_2$ were employed. Iron induced the greatest change, giving rise to the lowest specific gravity, viscosity, refractive index and acidity, and produced the highest percentage of unsaponifiable matter. Sodium hydroxide, as a catalyst, was a close second; while aluminum chloride was third.

Table 4 and chart 3 give distillation temperatures. Data for coconut oil and the fatty acids are included for comparison. The results show that at a distillation rate of a drop every two seconds with catalysts, liquids of distinctly lower distillation temperature ranges than either coconut oil or the fatty acids were produced. Fe_2O_3 and NaOH as catalysts produced the lowest distillation temperature curves; followed by $Ca\ Cl_2$, $Al\ Cl_3$ and $ZnCl_2$.

Table 5, giving the yield of liquid of various boiling point ranges, was constructed from chart 3 to determine how the distillates would measure up to gasoline and kerosene specifications. Specifications for gasoline required an initial boiling point of 32° to 40°C. and a maximum end point of 250°C. (Birne and Gohr, 1932). The corresponding requirements for kerosene are initial 193°C. and end point 288°C. In table 5, 200°C. is taken as end point for gasoline and 280°C., for kerosene. Column 1 of table 5 indicates 20 to 44 per cent of distillates within gasoline range, with NaOH and Fe as "best catalysts". The initial boiling points, however, do not come up to specifications, being too high. Column 2 shows 70 to 80 per cent yield of liquids within kerosene range; the initial boiling points, this time, more than meet requirements, being lower than specifications. The distillates, therefore, lie between gasoline and kerosene as regards boiling point characteristics. If the distillates are

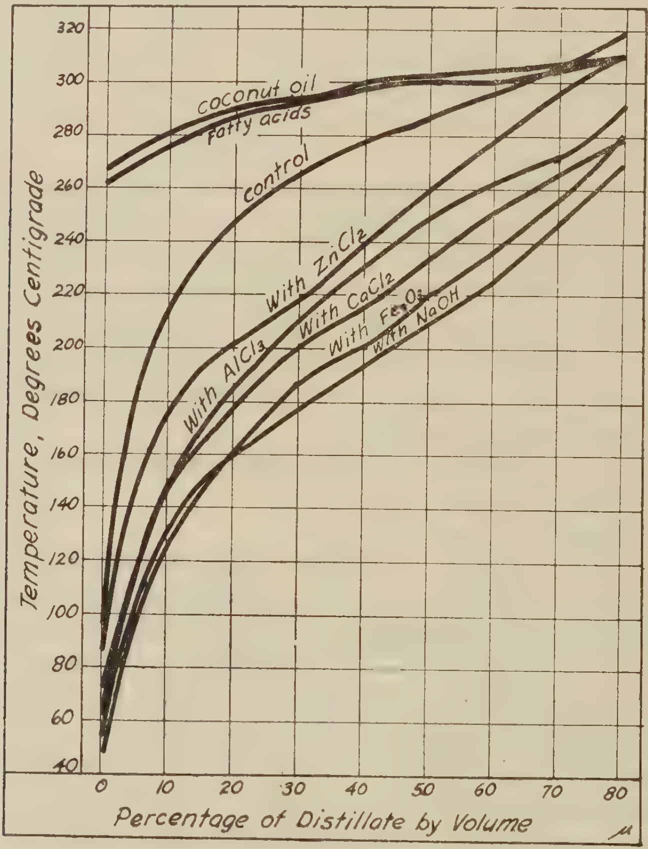

Chart 3.—Distillation temperatures of coconut oil and of of products obtained by the pyrolysis of coconut oil.

divided into three fractions, from lowest to 200°C, 200°C to 280°C. and 280°C. and above, then the relative yields are those given in columns 1, 3 and 4. According to these figures, 20 to 44 per cent are gasoline-like, 36 to 60 per cent are similar to kerosene.

Table 6 gives the distribution of acidity in the distillates. In general, acidity is high in the high-boiling fractions.

Table 6 also give the distributon of unsaponifiable matter. In general acidity is high in the high-boiling fractions.

Qualitative tests indicate that the distillates are highly unsaturated. Aromatics are detectable in some distillates by the nitration test especially those from NaOH. The aniline test for naphthenes is obscured by the solubility of unchanged coconut oil in aniline.

SUMMARY AND CONCLUSIONS

1. A study of the behavior of coconut oil under simple heat treatments has been made.

2. Coconut oil decomposed easily on heating to boiling and produced not only free fatty acids and acrolein but also a considerable amount of unsaponifiable matter which was mostly solid. This decomposition was followed by decrease in specific gravity and viscosity of the oil.

3. Catalysts like NaOH, $AlCl_3$, $ZnCl_3$,$CaCl_2$ and Fe hastened and produced greater changes. The liquid products exhibited flourescence effects, had very low viscosity, low flash point and low burning point and contained a very large proportion of liquid matter which was not saponifiable.

4. Ferric oxide (Fe_2O_3) seems to be the best catalyst, in the production of fluid liquids closely followed by NaOH and $AlCl_3$.

5. The distillation range of the treated oil samples has been brought down to low figures but is still too high to give a high yield of liquids of motor fuel range; about 20 to 50 per cent are within kerosene range.

ACKNOWLEDGMENT

For valuable suggestions and criticisms, thanks are due Dr. F. O. Santos, professor and head of the Department of Agricultural Chemistry. Thanks are also due Mr. Jesus Mamisao, of the Department of Soils, for the preparation of the charts and figures.

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TABLE 1

Comparative distillation of coconut oil and of its fatty acids: acidity unsaponifiable matter and distillation temperature range

	PER CENT BY VOLUME OF DISTILLATE											
	Start		0 - 10		10 - 20		20 - 40		40 - 60		60 - 80	
	Oil	Acids	Oil	Acids	Oil	Acids	Oil	Acids	Oil	Acids	Oil	Acids
Distillation temperature °C.	267	262	283	277	291	288	301	298	304	300	310	310
Acidity, millimols base/ml..	—	—	3.13	4.56	3.43	4.44	3.08	4.02	2.70	3.79	2.29	3.15
Unsaponifiable matter, per cent by volume	—	—	14.5	0.0	15.1	0.0	19.3	0.0	26.4	0.0	33.0	17.5

TABLE 2

Changes in some properties of coconut oil upon prolonged boiling

TIME OF HEATING Hours	TEMP. OF HEATING Degree C	SPECIFIC GRAVITY	VISCOSITY 30°C.	ACIDITY	UNSAPONIFIABLE MATTER
		30°/4°C.	Centipoises	Millimols base/ml.	Per cent by volume
0	30°	0.9145	35.9	0.09	0.0
1/4	360°	0.9141	35.1	0.09	0.0
1/2	350°	0.9141	36.1	0.09	0.0
1	340°	0.9087	33.3	0.45	1.0
2	330°	0.9051	30.3	0.95	8.9
5	310°	0.9009	27.8	1.33	14.8
10	290°	0.8976	solid	1.50	17.0
15	285°	0.8959	solid	1.63	20.8
20	280°	0.8943	solid	1.67	22.6

TABLE 3

Properties of various distillates produced from the pyrolysis of coconut oil

	SPECIFIC GRAVITY	VISCOSITY 30°C.	REFRACTIVE INDEX	BURNING POINT	ACIDITY	UNSAPONIFIABLE MATTER
	30°/4°C.	Centipoises	Abbe 30°C.	°C.	Millimols base/ml.	Per cent by volume
1. $AlCl_3$ catalyst	0.8116	2.31	1.4352	55	1.32	68.4
2. $BaCl_2$ ”	0.8291	3.34	1.4351	83	2.17	44.8
3. $CaAc_2$ ”	0.8209	2.22	1.4343	59	1.73	66.0
4. $CaCl_2$ ”	0.8225	2.21	1.4352	58	1.80	60.9
5. $CdCl_2$ ”	0.8314	3.55	1.4332	81	2.32	45.1
6. Fe_2O_3 ”	0.7940	1.64	1.4273	80	0.73	78.9
7. NaOH ”	0.7968	1.73	1.4363	47	0.95	76.0
8. $ZnCl_2$ ”	0.8200	3.33	1.4320	75	2.08	57.0
9. Control	0.8391	3.08	1.4377	68	2.63	34.0
10. Coconut oil .	0.9121	37.19	1.4547	250	0.09	0.0
11. Fatty acids .	0.8952	19.26	1.4420	182	4.40	0.0

TABLE 4

Distillation temperature range of coconut oil and of the products obtained from the pyrolysis of coconut oil

	DISTILLATION TEMPERATURES								
	0%	10%	20%	30%	40%	50%	60%	70%	80%
1. $AlCl_3$ catalyst	58	146	184	211	229	248	263	273	292
2 $CaCl_2$ ”	68	147	176	199	217	234	252	265	281
3. Fe_2O_3 ”	49	129	161	188	202	221	238	258	280
4. NaOH ”	54	130	160	179	194	210	224	248	271
5. $ZnCl_2$ ”	79	178	202	219	240	261	280	296	311
6.”Control	86	217	246	268	278	288	297	306	320
7. Coconut oil .	267	283	291	294	301	302	304	307	310
8. Fatty acids .	262	277	288	292	298	301	300	306	310

TABLE 5

Yields of liquids of various distillation-temperature ranges

BOILING POINT RANGE °C.	CATALYST					
	$AlCl_3$	$CaCl_2$	NaOH	Fe_2O_3	$ZnCl_2$	Control
	per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1. Initial b. p. to 200°C.	25	30	44	40	20	20
2. Initial b. p. to 280°C.	76	80	80	80	70	80
3. 200° to 280°C.	51	50	36	40	50	60
4. 280°C. and above ..	24	—	—	—	30	—
Initial b. p. degrees C .	58°	68°	54°	49°	79°	60°

TABLE 6

Acidity and unsaponifiable matter of various distillates obtained from the pyrolysis of coconut oil

	ACIDITY MILLIMOLS/BASE/ML.					UNSAPONIFIABLE MATTER PER CENT BY VOLUME				
	Per cent by volume of distillate					Per cent by volume of distillate				
	0 - 10	10 - 20	20 - 40	40 - 60	60 - 80	0 - 10	10 - 20	20 - 40	40 - 60	60 - 80
1. $AlCl_3$ catalyst ...	1.00	1.04	1.17	1.32	1.67	73.7	82.3	82.4	71.0	62.8
2. $CaCl_2$ " ...	1.34	1.41	1.14	1.95	2.34	75.5	80.3	76.0	62.0	48.6
3. Fe_2O_3 " ...	0.58	0.64	0.54	0.94	1.19	92.0	94.5	91.5	85.0	68.5
4. NaOH " ...	0.64	0.72	0.47	0.68	0.91	77.1	87.1	87.7	82.9	77.1
5. $ZnCl_2$ " ...	0.77	0.89	1.42	2.62	2.88	80.3	79.7	69.5	40.2	27.4
6 Control	0.74	1.22	1.89	3.21	3.52	73.6	75.5	64.6	36.3	23.2
7. Coconut oil	3.13	3.43	3.08	2.70	2.29	14.5	15.1	19.3	26.4	33.0
8. Fatty acids	4.56	4.44	4.02	3.79	3.15	0.0	0.0	0.0	0.0	17.5

A COMPARATIVE STUDY OF THE AMOUNT OF FECES VOIDED BY PHILIPPINE AND NELLORE CATTLE AND THE FERTILIZING CONSTITUENTS CONTAINED THEREIN [1]

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The objects of the study reported in this paper were as follows: (1) To determine the comparative amounts of feces voided by Philippine and Nellore cattle; (2) to find out the relationship between the amount of feces obtained from them and their live weight; and (3) to ascertain the quantity and value of fertilizing constituents contained in the feces.

The work was conducted in the Departments of Animal Husbandry and Agricultural Chemistry, College of Agriculture, University of the Philippines, from January, 1932 to June, 1936.

Cattle

Two breeds of cattle; namely, the Philippine and Nellore breeds were used in the experiment. There were five females and one bull in each group. All of them represented selected individuals of either breed, particularly the bulls, and had reached mature size. The average weight of the bull in the Philippine group during the investigation was 463.3 kgm., while that of the cows ranged from 219.1 to 260.9 kgm., the general average for the five being 242.5 kgm. With the Nellores, the average weight of the bull was 568.8 kgm., that of the cows varied from 314.8 to 364.4 kgm., the general average being 328.1 kgm. All animals were in good health and had normal appetite (table 1).

Feeding and management of animals

The animals used in this experiment were kept in a barn provided with concrete floor and iron roofing. They were given either sugar cane tops or Napier grass in amounts that would feed them fully during the day time. Feeding was made in the morning, noon

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[1] Experiment Station contribution No. 1171. Read before Los Baños Biological Club on September 24, 1936. Received for publication October 7, 1936.

and afternoon. All feeds left in the manger at 6:00 p. m. were removed so that the animals had all the night to rest and chew their cud. Water was supplied twice a day, in the morning and in the afternoon. The feces was collected in empty kerosene cans every morning, noon and afternoon, or oftener, and the weights were taken soon after collection. Samples for analysis were secured from fresh voidings by watching for the defecation of the animal in the morning and afternoon. The samples were placed in clean bottles and immediately prepared for chemical analysis.

The animals were placed in the barn for feeding, and feces collection in a group of either breed was made for a period of five days each time or longer, depending upon the quantity of feed available for them. The animals were kept in the barn for a longer period during the rainy months than during the dry season when the quantity of feed was limited. Actual feces collection was made for a total period of 30 days with each animal, with the exception of Philippine animals Nos. 54 and 158, and Nellore cow No. 6. The period of collection from Philippine cow No. 54 was 28 days; from Philippine bull No. 158, 27 days; and from Nellore cow No. 6, 29 days.

Analysis of feces

From the different samples of feces obtained, materials were set aside for determining the moisture, nitrogen and ash contents. From the ash of each sample, the inorganic substances like phosphoric acid, potash and lime, were then ascertained.

The methods of analysis used were in accordance with those indicated in the *Official and Tentative Methods of Analysis of the Association of Official Agricultural Chemists.*[2]

DISCUSSION OF RESULTS

Feces production

According to table 2, the range in the amount of feces passed out by Philippine cows in one day was from 4.0 to 22.0 kgm., the average being 11.4 kgm.; that of the Philippine bull, from 15.7 to 25.9 kgm., with an average of 20.3 kgm. The Philippine cows gave a minimum amount of 3,111.0 kgm. of feces in one year and a maximum production of 5,750.0 kgm., the average being 4,184.0 kgm.

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[2] Anonymous. 1930. Official and tentative methods of analysis of the association of Official Agricultural Chemists. 525 p., *25 fig.* Washington, D. C.: Association of Agricultural Chemists.

The Philippine bull gave 7,396.0 kgm. of feces in one year. The Nellore cows produced as low as 3.4 kgm. and as high as 20.0 kgm. of feces in one day, the average being 11.6 kgm. With the Nellore bull, the fluctuation was from 13.2 to 20.7 kgm., the average being 17.3 kgm. The yearly production among the cows of this breed was calculated to amount to an average of 4,217.3 kgm., the range being from 3,184.3 to 4,910.5 kgm. With the bull, the amount produced was 6,327.9 kgm. yearly.

The mean obtained by treating the daily feces record of the five Philippine cows statistically, is 11.59 ± 0.23 kgm. The mean for the Nellore cows is 11.55 ± 0.17 kgm. The difference between these two means is not significant, being one-seventh of its probable error. With the Philippine bull, the mean is 20.31 ± 0.40 kgm., while with the Nellore bull, it is 17.33 ± 0.29 kgm. In this case, the feces production is significantly greater in the Philippine bull than it is in the Nellore bull, the difference between the means being 6 times its probable error.

The coefficient of variation in the daily amount of feces produced by the bulls is 15.16 ± 1.41 with the Philippine animal and 13.68 ± 1.20 with the Nellore. Among the cows, the coefficient of variation is 35.81 ± 1.49 with the Philippine and 26.09 ± 1.08 with the Nellore.

It may be of interest to note that the Philippine cows used in this investigation consumed an average soilage of 21.2 kgm. and the Philippine bull 43.9 kgm. a head daily. In the case of the Nellore breed, the average daily consumption of soilage among the cows was 25.8 kgm. a head, and 40.0 kgm. with the bull.[3]

Quantity of feces voided in relation to live weight of animals

As shown in table 3, the amount of feces voided per 100 kgm. live weight of the cows in the Philippine group varied from 3.73 to 5.98 kgm., the average being 4.66 kgm. The Philippine bull gave an average of 4.38 kgm. of feces per 100 kgm. of its live weight. With the Nellore cows, the voidings ranged from 2.76 to 4.20 kgm. per 100 kgm. live weight, the average being 3.52 kgm. The amount of feces produced by the Nellore bull was 3.04 kgm. per 100 kgm. of its live weight.

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[3] From unpublished data in the Department of Animal Husbandry.

Chemical Analysis

The analysis of fresh feces is shown in table 4.

Moisture. The average percentage of moisture in the feces of Philippine cattle was 82.1, the variation ranging from 81.1 to 83.3 per cent. With Nellore cattle, the average was 82.5 per cent, the fluctuation being from 80.9 to 84.2 per cent. Van Slyke[4] gives the moisture content of the feces of the cow at 85.0 per cent.

Nitrogen. The amount of N in the feces of Philippine cattle varied from 0.21 to 0.33 per cent, the average for all animals being 0.27 per cent. In the feces of the Nellore animals, the minimum content of N was on an average 0.24 per cent and the maximum, 0.33 per cent, the average for all cattle being 0.28 per cent. According to Van Slyke, the average N content in the feces of the cow is 0.40 per cent, the fluctuation being from 0.30 to 0.45 per cent. It is evident that Van Slyke's figures are higher than the analysis obtained locally.

Phosphoric acid. The average percentage of P_2O_5 in the feces of Philippine cattle was 0.41, the variation being from an average of 0.20 to 0.74 per cent. Among the Nellore cattle, the analysis showed a range of 0.23 to 0.43 per cent, the average for all being 0.30 per cent. Van Slyke gives a lower percentage of this constituent, his average is only 0.20, and the range from 0.15 to 0.25 per cent.

Potash. The average percentage of K_2O in the feces of Philippine cattle was 0.20, the highest amount 0.27 per cent and the lowest 0.12 per cent. With the Nellore cattle, the amount varied from an average of 0.10 to 0.22 per cent, the average analysis for all being 0.15 per cent. Again Van Slyke gives a low figure with this constituent, his average being 0.10 per cent, the range being from 0.05 to 0.15 per cent.

Lime. The amount of CaO in the feces of Philippine cattle varied from an average of 0.17 to 0.37 per cent, the average for all being 0.27 per cent. In the feces of the Nellore animals, the fluctuation was from 0.21 to 0.47 per cent, the average for all being 0.35 per cent.

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[4] VAN SLYKE, LUCIUS L. 1920. Fertilizers and crops. XIV + 734 p., fig. 131 New York: Orange Judd Company.

Amount and cost of fertilizers[5]

The average amount of feces calculated to be produced by Philippine cows in one year is on an average of 4,184.0 kgm. a head. Using the average chemical analysis of the feces, the yearly production of the different fertilizers in the feces of each cow is as follows: N, 11.30 kgm.; P_2O_5, 17.15 kgm.; K_2O, 8.37 kgm. With the average yearly production of 7,396.0 kgm. of feces from the Philippne bull, the quantity of fertilizers it contains is estimated to be as follows: N, 19.97 kgm.; P_2O_5, 30.32 kgm.; K_2O, 14.79 kgm.

The average yearly production of feces of the Nellore cows was 4,217.3 kgm. a head. The amounts of fertilizers that may be derived from it follow: N, 11.81 kgm.; P_2O_5 12.65 kgm.; K_2O, 6.33 kgm. From the yearly feces production of 6,327.9 kgm. from the Nellore bull, the following quantities of fertilizers were obtainable: N, 17.72 kgm.; P_2O_5, 18.98 kgm.; K_2O, 9.49 kgm.

In money value, the amount of N produced in one year by each of the Philippine cows was worth ₱4.41; P_2O_5, ₱4.12; and K_2O, ₱2.01. With the bull, the yearly production of N amounts to ₱7.79; P_2O_5, ₱7.28; and K_2O, ₱3.55.

The Nellore cows gave as much as ₱4.61 worth of N a head a year; ₱3.04, of P_2O_5; and ₱1.52, of K_2O. The bull yielded N valued at ₱6.91 in one year; P_2O_5, ₱4.56; and K_2O, ₱2.28.

SUMMARY AND CONCLUSIONS

1. A comparative study on the amount of feces voided by Philippine and Nellore cattle and their fertilizing constituents are presented in this paper.

2. The average weight of the Philippine cows used in the investigation was 242.5 kgm.; that of the Nellore cows, 328.1 kgm. The mean weight of the Philippine bull was 463.3 kgm. and that of the Nellore bull, 568.8 kgm.

3. The average daily feces production among the Philippine cows was 11.4 kgm. a head; among the Nellore cows, 11.6 kgm. each. The amount corresponding to the Philippine bull was 20.3 kgm.; to the Nellore bull, 17.3 kgm. The difference between the means of the production of the cows of the two breeds is insignificant, that of the bulls being markedly in favor of the Philippine breed.

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[5] The quotations used in presenting the cost of fertilizers contained in the feces were obtained from Menzi and Co., Inc., Manila, on June 27, 1936. The price of sulfate of ammonia, with 20.6 per cent N, was ₱80.00 a ton; sulfate of potash, with an average of 49.0 per cent of K_2O, ₱120.00 a ton; and superphosphate, averaging 19.0 per cent P_2O_5, ₱45.00 a ton.

4. The estimated yearly production of feces of Philippine cows averages 4,184.0 kgm. a head; and that of the Nellore, 4,217.3 kgm. The average amount produced by the Philippine bull was 7,396.0 kgm. a year; the Nellore bull, 6,327.9 kgm.

5. The amount of feces passed out by the Philippine cows in relation to their live weight was 4.66 per cent of the weight of the animal; that of the Philippine bull, 4.38 per cent. That of the Nellore breed was 3.52 per cent among the cows and 3.04 per cent in the case of the bull.

6. The average chemical analysis of the feces of Philippine cattle is as follows: H_2O, 82.1 per cent; N, 0.27 per cent; P_2O_5, 0.41 per cent; K_2O, 0.20 per cent; CaO, 0.27 per cent. That of the Nellore follows: H_2O, 82.5 per cent; N, 0.28 per cent; P_2O_5, 0.30 per cent; K_2O, 0.15 per cent; CaO, 0.35 per cent.

7. The computed amounts of fertilizing constituents obtainable from one year's collection of feces from each of the Philippine cows follow: N, 11.30 kgm.; P_2O_5, 17.15 kgm.; K_2O, 8.37 kgm. From the Philippine bull, the amounts were: N, 19.97 kgm.; P_2O_5, 30.32 kgm.; K_2O, 14.79 kgm. From Nellore cows: N, 11.81 kgm.; P_2O_5, 12.65 kgm.; K_2O, 6.33 kgm. From the Nellore bull: N, 17.72 kgm.; P_2O_5, 18.98 kgm.; K_2O, 9.49 kgm.

8. The cost of fertilizers obtainable from the feces of each of the Philippine cows in one year follows: N, ₱4.41; P_2O_5, ₱4.12; K_2O, ₱2.01. The total value was ₱10.54. From the Philippine bull, the returns were: N, ₱7.79; P_2O_5, ₱7.28; K_2O, ₱3.55, making a total of ₱18.62. Among the Nellore cows, the income that may be obtained from the feces of a single animal is the following: N, ₱4.61; P_2O_5, ₱3.04; K_2O, ₱1.52. These amounts give a total of ₱9.17. That of the Nellore bull was ₱6.91 for N, ₱4.56 for P_2O_5, and ₱2.28 for K_2O, the total value being ₱13.75.

TABLE 1

Showing the sex, date of birth, height and average weight of cattle used

ANIMAL	SEX	DATE OF BIRTH	HEIGHT	AVERAGE WEIGHT
Herd No.			*cm.*	*kgm.*
Philippine cattle				
54	Female	Unknown (very old)	108.2	250.3
90	"	Unknown (medium age) ..	109.3	260.9
174	"	June 12, 1925	107.0	254.4
198	"	Nov. 12, 1930	106.3	219.1
215	"	Oct. 21, 1931	107.3	227.7
158	Male	Unknown (medium age) ..	129.0	463.3
Nellore cattle				
6	Female	Unknown (very old)	123.4	314.9
30	"	Aug. 8, 1922	122.4	324.8
34	"	Jan. 6, 1924	121.0	314.8
41	"	April 10, 1927	123.5	321.5
47	"	Unknown (medium age) ..	125.0	364.4
21	Male	Oct. 18. 1919	137.0	568.8

TABLE 2

Showing the amount of feces voided by cattle

ANIMAL	SEX	AMOUNT VOIDED IN 30 DAYS	RANGE IN AMOUNT VOIDED DAILY	AVERAGE DAILY PRODUCTION	CALCULATED YEARLY PRODUCTION
Herd No.		*kgm.*	*kgm.*	*kgm.*	*kgm.*
Philippine cattle					
54	Female	298.2 [a]	4.0–14.8	10.6	3,887.3
90	"	472.6	8.0–22.0	15.6	5,750.0
174	"	407.0	6.2–22.0	13.6	4,951.8
198	"	264.7	5.0–13.6	8.8	3,220.5
215	"	255.7	2.7–10.4	8.5	3,111.0
Average		343.9		11.4	4,184.0
158	Male	547.1 [b]	15.7–25.7	20.3	7,396.0
Nellore cattle					
6	Female	253.0 [c]	3.4–12.0	8.7	3,184.3
30	"	336.5	6.7–17.5	11.2	4,094.1
34	"	354.3	5.4–17.5	11.8	4,310.7
41	"	403.6	10.7–20.0	13.5	4,910.5
47	"	377.0	8.9–17.5	12.6	4,586.8
Average		343.9		11.6	4,217.3
21	Male	520.1	13.2–20.7	17.3	6,327.9

[a] This amount represents feces collection for 28 days; in [b], for 27 days; in [c], for 29 days.

TABLE 3

Showing the relationship between the live weight and amount of feces voided daily by cattle

PHILIPPINE CATTLE	AVERAGE LIVE WEIGHT	AVERAGE AMOUNT OF FECES VOIDED DAILY	AMOUNT OF FECES VOIDED DAILY PER 100 KGM. LIVE WEIGHT	NELLORE CATTLE	AVERAGE LIVE WEIGHT	AVERAGE AMOUNT OF FECES VOIDED DAILY	AMOUNT OF FECES VOIDED DAILY PER 100 KGM. LIVE WEIGHT
Herd No.	*kgm.*	*kgm.*		*Herd No.*	*kgm.*	*kgm.*	
Cows				Cows			
54	250.3	10.6	4.23	6	314.9	8.7	2.76
90	260.9	15.6	5.98	30	324.8	11.2	3.45
174	254.4	13.6	5.35	34	314.8	11.8	3.75
198	219.1	8.8	4.02	41	321.5	13.5	4.20
215	227.7	8.5	3.73	47	364.4	12.6	3.46
Average	242.5	11.4	4.66	Average	328.1	11.6	3.52
Bull				Bull			
158	463.3	20.3	4.38	21	568.8	17.3	3.04

TABLE 4

Showing the average composition of feces of Nellore and Philippine cattle

ANIMAL	NUMBER OF SAMPLES	H_2O	N	P_2O_5	K_2O	CaO
Herd No.		*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Philippine cattle						
54	3	81.2	0.33	0.20	0.14	0.37
90	7	83.3	0.26	0.49	0.16	0.18
158	3	81.1	0.27	0.24	0.21	0.36
174	5	83.2	0.22	0.26	0.12	0.17
198	7	81.7	0.34	0.74	0.27	0.25
215	5	82.1	0.21	0.55	0.27	0.28
Average		82.1	0.27	0.41	0.20	0.27
Nellore cattle						
6	4	84.2	0.28	0.26	0.22	0.47
21	4	81.3	0.30	0.27	0.15	0.37
30	5	82.3	0.33	0.23	0.20	0.35
34	3	83.3	0.27	0.32	0.12	0.46
41	5	80.9	0.24	0.30	0.11	0.21
47	5	83.0	0.25	0.43	0.10	0.26
Average		82.5	0.28	0.30	0.15	0.35

THE AMOUNT AND VALUE OF PLANT FOOD IN THE SOLID EXCRETA OF PHILIPPINE CARABAOS[1]

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In line with the series of investigations carried out in the College of Agriculture on the amount of fertilizing matter contained in the solid excreta of farm animals, the work presented here has been performed to determine (1) the quantity of solid excreta passed out by Philippine carabaos and its relation to the live weight of the animal, and (2) the amount and cost of plant food it contains.

The work was conducted in the Departments of Agricultural Chemistry and Animal Husbandry, College of Agriculture, University of the Philippines. It was started in January, 1935, and ended in July, 1936.

Animals

Five mature Philippine carabao cows were used in the experiment, the age ranging from about five years and nine months to a little over nineteen years. The height of the animals averaged 127.5 cm. while the weight averaged 470.1 kgm. All animals were in good health and showed normal feeding habits. (Table 1).

Feeding and management

The carabaos were housed in a barn provided with a concrete floor. They were placed in their respective stalls at all times throughout each period of feces collection, the duration lasting for as many days as there were forages to supply them. The longest period was 24 days.

The feeds consisted of Guatemala grass (*Tripsacum laxum* Nash), Napier grass (*Pennisetum purpureum* Schum.), corn forage and mixed grasses composed mainly of culape (*Paspalum conjugatum* Berg.), depending on which of them was available at different months of the year. In all cases, during the time when feces was collected for chemical analysis, Napier grass was given to the animals. Feeding was made from 6.00 a. m. to 6:00 p. m., in the morning, at noon and in the afternoon. Enough feed was given to the animals as would be consumed to their full satisfaction. Water was supplied in the morning and afternoon. Salt was given three times a week.

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[1] Experiment Station contribution No. 1166.

Collection and sampling of feces

The feces was collected for a period of 100 days from each animal. The voidings from six o'clock in the morning to the same hour the next morning constituted the production for one day. During the daytime, the excreta was gathered and placed in cans in the morning and afternoon, while the night excrement was collected early in the morning. Weighing of the feces was made twice daily, first the night excreta and next the amount passed out during the day. Samples for analysis were obtained from freshly voided feces. This was done usually at about nine o'clock in the morning by watching for the defecation of each animal. Soon after the sample was collected, it was taken to the laboratory for analysis.

Chemical analysis

Determinations were made of the percentage amount of moisture, nitrogen, phosphoric acid, potash and lime contents of the feces samples. The methods of analysis were followed according to the procedure prescribed by the Association of Agricultural Chemists.[2]

DISCUSSION OF RESULTS

Feces production

Table 2 shows the amount of feces yielded by the different carabaos used in the investigation. The smallest average daily yield amounted to 15.3 kgm. with carabao No. 89, the largest being 22.0 kgm. with carabao No. 122. The general average was 18.8 kgm. The range in the daily yield in all animals was from 7.1 to 34.8 kgm. The actual production in 100 days varied from 1,532.6 kgm. with animal No. 89 to 2,202.0 kgm. with animal No. 122, the average being 1,877.5 kgm. In terms of one-year production, the computed yields ranged from 5,594.0 kgm. to 8,037.3 kgm., the average being 6,853.0 kgm.

Percentage of feces to live weight of carabaos

Table 3 shows the percentage of feces in relation to the live weight of the animals. The average percentage was 4.0, the range being from 3.4 with carabao No. 89 to 4.5 with carabao No. 64.

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[2] Anonymous. 1930. Official and tentative methods of analysis of the Association of Official Agricultural Chemists. 525 p., 25 fig. Washington, D. C.; Association of Agricultural Chemists.

Chemical composition

Table 4 shows the moisture and plant-food constituents of the feces of the different carabaos.

Moisture. The average content of H_2O in the feces of all carabaos was 82.9 per cent, the range being from an average of 82.1 per cent with carabao No. 89 to an average of 83.9 per cent with carabao No. 64.

Nitrogen. The N content in the feces of all animals averaged 0.27 per cent, the smallest average percentage being 0.22 with carabao No. 9 and the largest 0.33 with carabao No. 89.

Phosphoric acid. The amount of P_2O_5 in the feces of carabaos is greater than that of the other fertilizing constituents, the average in all animals being 0.63 per cent. The lowest percentage averaged 0.53 with carabao No. 64 and the highest was 0.76 with carabao No. 83.

Potash. K_2O was low in the feces of all carabaos, the average percentage being 0.14. It varied from an average of 0.11 per cent in carabao No. 83 to an average of 0.17 per cent in carabaos Nos. 9 and 64.

Lime. The CaO content was also low in carabao's feces, although slightly higher than the K_2O it contains. The average percentage of CaO in the feces of all animals amounted to 0.17, the variation was from an average of 0.13 per cent with animal No. 64 to 0.20 per cent in the case of carabao No. 9.

Quantity and value of plant food in one year's collection of feces[3]

With an estimated annual collection of feces averaging 6,853 kgm. from each carabao, the amounts of the various fertilizing constituents that may be obtained from it, on the basis of the average chemical analysis, are as follows: N, 18.50 kgm.; P_2O_5, 43.17 kgm.; K_2O, 9.59 kgm. The corresponding value of each constituent is ₱7.22 with N, ₱10.36 with P_2O_5, and ₱2.30 with K_2O, the total amounting to ₱19.88.

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[3] The prices of fertilizers on which computations on the value of plant-food materials in the feces of carabaos were based were obtained from Menzi & Co., Inc., Manila, on June 27, 1936, as follows: Sulfate of ammonia, with 20.6 per cent N, at ₱80.00 a ton; sulfate of potash, with an average of 49.0 per cent of K_2O, at ₱120.00 a ton; and superphosphate, with an average of 19.0 per cent P_2O_5, at ₱45.00 a ton.

SUMMARY AND CONCLUSIONS

1. A study on the amount of plant-food constituents contained in the solid excreta of Philippine carabaos is presented here.

2. Five mature carabao cows were used. They averaged 127.5 cm. in height and 470.1 kgm. in weight.

3. The production of feces averaged 18.8 kgm. a head a day. In one year the yield averaged 6,853 kgm.

4. The percentage of feces in relation to the live weight of the animal averaged 4.0.

5. The average chemical composition of the feces was as follows: H_2O, 82.9 per cent; N, 0.27 per cent; P_2O_5, 0.63 per cent; K_2O, 0.14 per cent; CaO, 0.17 per cent.

6. The amounts of plant-food materials obtainable from each animal are as follows: N, 18.50 kgm.; P_2O_5, 43.17 kgm.; K_2O, 9.59 kgm.

7. Computed on the basis of market prices of fertilizers, the value of the different constituents follows: N, ₱7.22; P_2O_5, ₱10.36; K_2O, ₱2.30. Total, ₱19.88.

TABLE 1

Showing the date of birth, height and average weight of Philippine carabaos

ANIMAL NO.	DATE OF BIRTH	HEIGHT	AVERAGE WEIGHT
		cm.	*kgm.*
9	July 15, 1917	131.0	480.2
64	August 28, 1928	126.5	443.4
83	September 24, 1930	128.0	480.8
89	December 8, 1930	125.0	450.0
122	Unknown (medium age) ..	127.0	499.5

TABLE 2

Showing the amount of feces voided by Philippine carabaos

ANIMAL NO.	AMOUNT VOIDED IN 100 DAYS	RANGE IN AMOUNT VOIDED DAILY	AVERAGE DAILY YIELD	CALCULATED YEARLY PRODUCTION
	kgm	*kgm.*	*kgm.*	*kgm.*
9	1,984.7	10.7–34.8	19.9	7,244.2
64	1,979.1	7.1–32.5	19.8	7,223.7
83	1,689.2	10.2–29.9	16.9	6,165.6
89	1,532.6	7.6–25.2	15.3	5,594.0
122	2,202.0	12.7–34.5	22.0	8,037.3
Average	1,877.5	—	18.8	6,853.0

TABLE 3

Showing the percentage of feces in relation to the live weight of Philippine carabaos

ANIMAL NO.	AVERAGE LIVE WEIGHT OF ANIMAL	AVERAGE AMOUNT OF FECES VOIDED DAILY	PERCENTAGE OF FECES VOIDED DAILY IN RELATION TO LIVE WEIGHT OF ANIMALS
	kgm.	*kgm.*	
9	480.2	19.9	4.1
64	443.4	19.8	4.5
83	480.8	16.9	3.5
89	450.0	15.3	3.4
122	499.5	22.0	4.4
Average	470.1	18.8	4.0

TABLE 4

Showing the average chemical composition of feces of Philippine carabaos

ANIMAL NO.	NUMBER OF SAMPLES	H_2O	N	P_2O_5	K_2O	CaO
9	5	83.1	0.22	0.65	0.17	0.20
64	6	83.9	0.26	0.53	0.17	0.13
83	8	82.4	0.27	0.76	0.11	0.18
89	6	82.1	0.33	0.61	0.13	0.17
122	5	82.6	0.28	0.58	0.14	0.19
Average ..	—	82.9	0.27	0.63	0.14	0.17

STUDIES ON THE PHYSICAL QUALITIES OF THE HEN'S EGG: VI. INFLUENCE OF FEEDS ON THE PHYSICAL QUALITIES OF NEW-LAID LOS BAÑOS CANTONESE EGGS [1]

F. M. FRONDA AND VIRGINIO C. JUAN

Eggs that are offered for sale in the markets differ in size, and in the color and the texture of the shells. When the contents are examined, differences in quality and in the color of both the yolk and the albumen may be noted. It is apparent that many local egg buyers are beginning to realize that not all eggs are good eggs and are now willing to pay the price asked for "quality eggs." A number of egg dealers report also that consumers are beginning to develop preferences in egg yolk color, and further claim that eggs of a certain shell color apparently sell faster than others.

Since the physical qualities of new-laid Los Baños Cantonese eggs have been observed to be influenced by seasonal changes (Fronda, Clemente and Basio, 1935), it would be of interest to determine the effects of feeds on these characters of the egg. Does the feed given to the flock affect the different physical characters of new-laid eggs? If so, in what ways are these influenced? To be able to answer these questions the observations herein reported were made.

These studies were conducted in the Poultry Laboratory of the Department of Animal Husbandry, College of Agriculture, University of the Philippines, from January to August, 1934.

Review of literature

Available literature on this subject are mostly reports on the influence of the feed on the size of the egg and on the color of the yolk. Information on the effect of feeds on the other characters of the contents of the egg is wanting.

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[1] The data presented in this paper were taken from the thesis presented by the junior author for graduation, 1935, with the degree of Bachelor of Science in Agriculture, from the College of Agriculture, University of the Philippines, No. 519; Experiment Station contribution No. 1168. Received for publication, November 27, 1936.

Parkhurst (1927) reported as a result of six years of study that the size of the egg is influenced materially by the ration fed. The same investigator in 1933 definitely showed that an all-in-one ration in pellet form gave a somewhat larger egg size than the same ration in mash form. Newman (1927), as cited by Parkhurst (1933), reported that pullets fed on corn lay a higher percentage of first grade eggs than those fed on wheat. Chan and Guiyab (1934) reported that hens fed with corn lay heavier eggs than those fed with equal amounts of corn and palay, although there was no significant difference obtained when corn alone was compared with palay alone. Atwood (1926) reported that a poorly balanced ration not only restricted the production of eggs during winter but also reduced the weight of the eggs 12 per cent. The addition of milk products to the ration, however, increased the size of the eggs (Kistler, Charles and Knandel, 1926).

Lippincott and Card (1934) state that green feed and yellow corn help to impart a rich golden yellow color, and excessive amounts of linseed meal give a green color to the yolk. Waite (1911) reported that yellow corn, when composing three-sevenths of a ration, imparted a very deep yellow color to the yolk, but if corn composed only three-elevenths, only a noticeable yellow tint is produced. Both wheat and white corn, given in the same proportions, did not produce yellow yolks. Payne (1925) showed that shepherd's purse, *Capsella bursa-pastoris*, and penny cress, *Thlaspi arvense*, both plants belonging to the mustard family, impart an olive color to the yolk. In 1927, Morgan and Woodroof reported that the feeding of 0.5 gram of dried *pimiento* pepper per hen per day produced a desirable color to the yolk and that dark reddish-brown color of the yolk could be produced by increasing the amount of pimiento pepper to 5 grams daily.

Henderson and Wilcke (1933) who conducted studies to determine whether or not factors other than the feed influence the color of the egg yolks concluded that the pigment in the ration of the hen is primarily responsible for the color of the yolk of the egg she produces. These investigators also reported that the time required for the feed to exert the initial visible influence on the color of the egg yolk is between 3 and 5 days, depending on how soon eggs are laid after feeding begins.

PLAN OF THE STUDY

In these observations, 1560 new-laid Los Baños Cantonese eggs were used. The eggs were collected from four separate pens fed with the following rations:

FEEDS	LOT 1	LOT 9	LOT 3	LOT 4
	parts	*parts*	*parts*	*parts*
Corn	10 [a]	10 [a]	10 [b]	8 [c]
Rice bran	4	6	4	4
Copra meal	3	1	3	3
Corn meal	1	1	1	1
Shrimp meal	2	2	2	2

[a] Corn fed as grain.
[b] Corn ground and mixed with the mash.
[c] Corn ground and mixed with the mash with 2 parts molasses by weight.

There were 400 eggs studied from lot 1, 383 eggs from lot 2, 391 eggs from lot 3 and 386 eggs from lot 4.

All eggs were studied within twenty-four hours after they were collected from the pens. The following characters were observed: (*a*) texture and color of the shell; (*b*) weight of the egg; (*c*) size of the air cell; (*d*) volume of the egg; (*e*) angle of inclination of the egg when submerged in water; (*f*) weight and thickness of the shell; (*g*) color of the yolk; (*h*) size of the yolk; (*i*) strength of the yolk; (*j*) amount of the albumen; and (*k*) color of the albumen. Except in a few minor modifications, which are indicated in the discussions, the methods used in studying these characters were similar to those employed by Fronda and Clemente (1934).

RESULTS AND DISCUSSIONS

Texture and color of the shell. By reference to table 1 it may be seen that the feed used in this study apparently did not affect the texture of the egg shell materially, although the molasses fed lot, lot 4, had the tendency to produce poorer shells than the other three lots. Lots 1 (grain and 4-3-1-2 mash) and 4 (molasses) had a slightly higher percentage of tinted shells. The relatively insignificant difference in the quality of the shell in all the lots may have been due to the accessibility of all the pens to seashore sand, used as litter, which supplies both grit and shell. The insignificant difference in the color of the shells may have been due to the individual characteristics of the birds in the different pens studied.

Fronda and Clemente (1934) observed that 54 of the 100 new-laid Los Baños Cantonese eggs that they studied had light-brown shells, 25 had brown and 21 had tinted. In this study, 65.00 per cent of the eggs in lot 1 (grain and 4-3-1-2 mash) were light-brown, 73.39 per cent in lot 2 (grain and 6-1-1-2 mash), 73.40 per cent in lot 3 (all mash) and 64.50 per cent in lot 4 (molasses). It may be seen from these percentages that the Los Baños Cantonese breed of chickens produces egg shells most of which are light-brown in color.

Size of the egg. From table 2 it may be seen that the lots fed with whole corn, lots 1 and 2, produced heavier eggs than those fed with all-mash. The eggs in lot 2 were the heaviest, having a mean weight of 43.383 ± 0.156 grams with a standard deviation of 4.539 ± 0.110; those in lot 4 (molasses) were the lightest with a mean weight of only 41.462 ± 0.109 grams with a standard deviation of 3.185 ± 0.077. Comparing lot 1 (whole corn) with lot 4 (molasses), it may be seen that the eggs in lot 1 weighed just slightly more than those in lot 4.

Molasses being a feed that easily ferments, hence, is acidic in reaction, may have caused some disturbances in the body of the birds, which may have affected, directly or indirectly, the size of the eggs produced. Copra meal as a feed for laying hens is not favorable for egg production (Taleon, 1924). This fact may have been the reason why lot 2 (grain and 6-1-1-2 mash) which received the smallest amount of this feed produced decidedly heavier eggs than any of the other three lots.

Fronda and Clemente (1934) reported that the eggs that they studied had a mean weight of 43.0 ± 0.3057 grams. Comparison of the weights of the eggs found in this study with the weights these investigators reported, reveals that they were almost the same, with the exception of those in lot 4 (molasses) which were significantly lighter with a difference of 1.768 ± 0.324.

Considering the volume of the egg, it may also be seen from the same table that the eggs in lot 2 (grain and 6-1-1-2 mash) were the largest and those in lot 4 (molasses) were the smallest. Apparently, the results in the study of the volume followed the same trend as that of the egg weight. Comparing the grain-fed lots (lots 1 and 2) with the all-mash fed lots, it may be seen that there was a tendency for corn when fed as grain to produce heavier and larger eggs than when it is ground and fed with the mash.

Specific gravity of the egg. From table 2 it may be seen also that the specific gravity of the eggs from the lots fed with whole corn (lots 1 and 2) was higher than that of the eggs from the all-mash fed lots. The eggs from lot 1 (grain and 4-3-1-2 mash) had the highest specific gravity, 1.0708 ± 0.0003; those from lot 3 had the lowest, 1.0565 ± 0.0006. The difference between lots 1 and 2 was 0.0043 ± 0.0015; between lots 3 and 4, 0.0089 ± 0.0021; and between lots 2 and 3, 0.0100 ± 0.0007. Comparing the specific gravity of the eggs found in this study with that found by Fronda and Clemente (1934) which was 1.056 ± 0.0089, no significant difference was observed.

Angle of inclination of the egg when submerged in water. From table 2 it may be seen that the all-mash fed lots, lots 3 and 4, produced eggs that formed a larger angle of inclination when submerged in water than that in the grain fed lots. The mean angles of inclination were: 9.753 ± 0.057 degrees in lot 1, with a standard deviation of 1.713 ± 0.040; 9.956 ± 0.056 degrees in lot 2, with a standard deviation of 1.651 ± 0.040; 10.717 ± 0.056 degrees in lot 3, with a standard deviation of 1.662 ± 0.040; in lot 4 (molasses), 11.033 ± 0.056 with a standard deviation of 1.641 ± 0.039.

When the two "grain" lots (lots 1 and 2) were compared, no significant difference was observed, but when the all-mash fed lots (lots 3 and 4) were compared, the angle of inclination of lot 4 was greater than that of lot 3 by 0.316 ± 0.080, a significant difference. When lot 2 (grain and 6-1-1-2 mash) was compared with lot 3, (all-mash), the difference was 0.661 ± 0.080, which was also significant.

Comparing the results obtained in this study with the angle of inclination reported by Fronda and Clemente (1934), which was 10.840 ± 0.181, it may be seen that the all-mash fed lots were almost the same and the grain fed lots were smaller. The results of these investigators when compared with lot 1 of the present study gave a difference of 1.087 ± 0.189, and with lot 2, a difference of 0.984 ± 0.189. These significant differences may have been due to the difference in the feeds used, as well as to the difference in the weather conditions when the observations were made.

Size of the air cell. From table 2 it may be seen that there is a tendency for the all-mash fed lots (lots 3 and 4) to produce eggs with larger air cells than the grain fed lots (lots 1 and 2). No significant difference, however, was found between lot 1 and lot 2; and between lot 3 and lot 4. These results seem to show that, apparently, the size of the air cell is influenced by the form of feed given to the birds, that is, ground corn, when fed with the mash, produced larger air cells than when it was fed in the form of grain. Fronda and Clemente (1934) reported that the 100 new-laid eggs that they studied had a mean height of the air cell of 0.140 ± 0.0012 centimeter and a mean diameter of 1.323 ± 0.0081 centimeters. All the lots in the present work had smaller air cells than those reported by these investigators. The difference may have been due to the difference in the ration used and the influence of weather conditions during which the observations were made.

Considering the air-cell index of the egg, it was observed, that lot 1, (grain and 4-3-1-2 mash) had the lowest and those in lot 2 (grain and 6-1-1-2 mash) had the highest. Comparing lot 1 with lot 3, which had the second lowest air cell index, a difference of 0.0025 ± 0.0005 was observed. There was, however, no significant difference between lots 2, 3 and 4. Fronda and Clemente (1934) reported that the air cell index of the 100 new-laid eggs that they studied was 0.108 ± 0.0006. Comparing lot 2 which had the highest air cell index in the present study with the air cell index that these investigators reported, a difference of 0.0024 ± 0.0006 was obtained, showing that all the lots studied had lower air cell indices.

Weight and thickness of the shell. After studying the external characters of the eggs they were broken one by one for internal examination. The contents of each egg were placed in a Petri dish and the halves of the shell were carefully freed of all adhering albumen by allowing it to run into the dish with the rest of the albumen. The shell was weighed, then its thickness was measured with a micrometer caliper at three points; namely, at the tip, at the middle and at the butt. Before measuring the thickness of the shell, the shell membranes were first carefully peeled off.

From table 2 it may be seen that there was no significant difference in the weight of the shell in lots 1, 2 and 3. The heaviest shell among the three lots was observed in lot 2 (grain and 6-1-1-2 mash) being 4.878 ± 0.019 grams with a standard deviation of 0.554 ± 0.0135. The lightest, 4.745 ± 0.0165 grams with a standard deviation of 0.483 ± 0.0117, was observed in lot 4 (molasses). The difference between lots 2 and 4 was 0.133 ± 0.047 which was significant.

Comparing the thickness of the shell, there was no significant difference observed between the first three lots although lot 4 (molasses) produced slightly thinner shells at the three points measured. In all cases the shell at the middle of the egg was observed to be thicker than at either end. The thickness ranged from 0.25 to 0.38 millimeter, with an average of 0.305 millimeter at the tip, 0.319 mm. at the middle and 0.304 mm. at the butt. There was no significant difference between the thickness of the shell at the tip and at the butt. Holst, Almquist and Lorenz (1932) reported that the thickness of the shell of 250 eggs that they studied was 0.330 millimeter for those with good shell and 0.321 millimeter for both with medium and poor shell. Almquist and Burmester (1934) reported that the mean thickness of 20 normal shells that they studied was 0.341 ± 0.001 millimeter. The difference between the results reported in this study and those reported by these investigators may have been due to breed differences. Another reason may have been due to the differences in the feeds used. Taylor and Martin (1928) in their studies on factors influencing the thickness of eggshell concluded that the lack of an adequate calcium supply in chemical combination available to the hen for the manufacture of egg shell will tend to produce thin-shelled eggs. They also observed that the lack of sufficient amounts of Vitamin D will also produce thin or soft-shelled eggs.

Color of the yolk. The yolk color of the eggs studied was classified into three groups; namely, light, medium, and dark. Because of the subjective interpretations of the terms "light", "medium", and "dark" by different individuals, a representative picture of these three classes of yolks with the colors accurately reproduced was used for comparison. The picture used was from Thomsen and Winton (1933) which they classified as follows:

"Light"—Munsell color reading 2Y $\frac{7}{11}$

"Medium"—Munsell color reading 9YR $\frac{6.5}{11}$

"Dark"—Munsell color reading 7Y $\frac{6}{11}$

Table 3 shows the results of the study on yolk color. From this table it may be seen that the all-mash fed lots (lots 3 and 4) produced eggs with much lighter colored yolk than those fed with grain and mash (lots 1 and 2). When whole corn was fed in the amount of fifty per cent of the ration, from 60 to 67 per cent of the eggs produced had a dark yolk. Increasing the amount of copra meal in the ration had no visible effect on yolk color. This was expected because copra meal contains very little, if any, xanthophyll, which produces yellow color on the yolk. The all-mash fed lots (lots 3 and 4) had only about 5 to 4 per cent, respectively of the dark colored yolk. In lot 3, 57.29 per cent were medium and in lot 4, 56.48 per cent were light. From the results obtained it may be stated that molasses incorporated in the ration had the tendency to produce light colored yolk.

The pigment in the ration of the hen is primarily responsible for the color of the yolk (Henderson and Wilcke, 1933). A careful study of the rations used in this study will show that the first three lots received corn comprising 55 per cent of the ration. Because yellow corn is very rich in xanthophyll and the birds having had ready access to green grass, the ration may be said to have abundant coloring matter which was imparted to the yolk.

The significant difference between lots 1 and 3, however, invites attention. Both lots received the same amount of corn, except that the corn was given as grain in lot 1 and in lot 3, ground and fed with the mash. It might be that corn loses a considerable amount of its xanthophyll when ground and kept a while. In this study, the ground corn used was exposed about one week before it was fed to the birds. The conspicuously light yolk from the molasses fed lot, lot 4, may be accounted for in a similar way, in addition to the fact that there was a smaller amount of corn in the ration (45 per cent). Although the birds had ready access to green grass, the amount of xanthophyll taken in might have been just sufficient to impart a yellow color to the yolk, but not abundant enough to produce a deep color. Thomsen and Winton (1933) and Elliot and Card (1933) observed that hens fed from 50 to 60 per cent yellow corn without access to green feed produced medium yolk.

Size of the yolk. While the yolk was still with the albumen, its height and diameter were measured with a caliper. From these measurements the "yolk index" was determined by dividing the height by the diameter. The yolk was later separated from the albumen by pouring the two together on the fingers and allowing the albumen to pass through. The yolk was freed, as much as possible, from clinging albumen before it was weighed.

It may be seen from table 2 that the eggs from the whole corn fed lots had heavier yolks than those from the all-mash fed lots. When lots 1 and 2 were compared, no significant difference was observed in the weight of the yolk but when lots 3 and 4 were compared the difference was significant. The mean weight of the yolk in lot 1 (whole corn and 4-3-1-2 mash) was 13.795 ± 0.056 grams with a standard deviation of 1.690 ± 0.040; in lot 2, 13.609 ± 0.047 grams with a standard deviation of 1.386 ± 0.047; in lot 3 (all-mash), 12.998 ± 0.050 with a standard deviation of 1.469 ± 0.035; while in lot 4 (molasses), 12.712 ± 0.041 grams with a standard deviation of 1.204 ± 0.029. Comparing the different lots, it was observed that the differences were: lot 1 with lot 2, 0.186 ± 0.073; lot 1 compared with lot 3, 0.797 ± 0.075; lot 1 with lot 4, 1.083 ± 0.062; lot 3 with lot 4, 0.283 ± 0.064. From this comparison it may be seen that all the differences between the lots compared were significant, except that of between lots 1 and 2, which was insignificant.

The figures obtained in this study show that hens fed with whole corn laid eggs with heavier yolks than those fed with corn in the form of mash. The yolks of eggs from the molasses fed lot (lot 4) were decidedly lighter than any of the other three lots, showing that this feed does not only produce a yolk lighter in color, but also lighter in weight. Considering the relation of the weight of the yolk to the weight of the egg, it was found that in lot 1 the yolk was 32.20 per cent of the egg; in lot 2, 31.36 per cent; in lot 3, 30.64 per cent; and in lot 4, 30.64 per cent.

Thickness and diameter of the yolk. From table 2 it may be seen that there was some difference in the thickness of the yolk in the four lots. When statistically treated, however, only the differences between lot 1 (grain and 4-3-1-2 mash) and the other three lots were significant, lot 1 producing the thickest yolk. The thickness of the yolk in the different lots was: in lot 1, 1.821 ± 0.002 centimeters; in lot 2, 1.793 ± 0.003 cm.; in lot 3, 1.785 ± 0.003 cm. and in lot 4, 1.793 ± 0.002 cm. Comparing the different lots, the differences observed were: lot 1 with lot 2, 0.038 ± 0.003; lot 1 with lot 3, 0.036 ± 0.003; lot 1 with lot 4, 0.034 ± 0.003; lot 2 with lot 3, 0.008 ± 0.004; and lot 3 with lot 4, 0.002 ± 0.003. All the yolks observed in this study were lower than those reported by Fronda and Clemente (1934) as was found by comparing the results from the two studies.

Regarding the diameter of the yolk, it was found that the grain-fed lots (lots 1 and 2) produced yolks with longer diameter than the all-mash fed lots (lots 3 and 4). A significant difference was found not only between the grain-fed lots and the all-mash fed lots but also between lots in the same group. When the four lots were compared, the differences were: lot 1 with lot 2, 0.034 ± 0.006; lot 1 with lot 3, 0.083 ± 0.005; lot 1 with lot 4, 0.136 ± 0.005; lot 2 with lot 3, 0.0049 ± 0.005; lot 2 with lot 4, 0.102 ± 0.005; lot 3 with lot 4, 0.053 ± 0.004. Comparing the results obtained in this study with those which were reported by Fronda and Clemente (1934), it was found that while lots 1 and 2 agree with their findings, lots 3 and 4 were significantly smaller. It is likely that the difference was due to the kind of feed used and to weather conditions when the observations were made.

Yolk index. From table 2 it may be seen that there were only very slight differences in the yolk indices in the different lots. Statistical study of the yolk indices of all the lots shows that the yolk index of eggs from lot 1 (grain and 4-3-1-2 mash) was 0.464 ± 0.0007 which was significantly higher than that of the other three lots. Lot 3 (all-mash), which had a yolk index of 0.4606 ± 0.0006, was the second highest. Comparing these two lots which received the same kind of feed, except that whole corn was fed in lot 1, and in lot 3 the corn was ground and fed with the mash, it was found that the difference was 0.007 ± 0.0009, which was also significant. A statistical study of the other three lots, lots 2, 3 and 4, showed no significant differences. Fronda and Clemente (1934) reported that the yolk index of the eggs that they studied was 0.472 ± 0.0027. Comparing the yolk index of lot 1 in the present study with the result of these investigators, the difference was 0.008 ± 0.0027. Only lot 1 compared favorably with the results of these investigators; the other three lots produced eggs which had decidedly lower yolk indices.

Strength of the yolk. The strength of the yolk was determined by the method suggested by Peters (1931), that is, by transferring it from the palm of one hand to the other, counting the number of times this could be done without breaking. To maintain an approximately uniform distance, the palms were held parallel with the tips of the thumbs touching. Thus, the hands formed a simple device and the yolk was thrown back and forth from the palms by half revolving the hands. The distance between the hands in this study was about sixteen centimeters.

The strength of the yolk was observed to be the most variable character of the egg. The yolk of the eggs could be transferred without breaking from palm to palm of the hands from 3 to 130 times with a coefficient of variation of about 73 per cent. It may be seen from table 2 that the yolks from the whole corn-fed lots were the strongest and could be transferred 37 times. The yolk from the molasses-fed lot, lot 4, were the weakest, having a strength of only 20 times and the yolks from lot 3 (all-mash) had a strength of 29. Fronda and Clemente (1934) reported that 74 per cent of the eggs that they studied could be transferred from palm to palm 41 times or more. The difference between the strength of yolk that they reported and that which is reported in this study may have been due to the difference in the distance between the palms while transferring the yolk.

Amount of the albumen. The albumen, after it was separated from the yolk, was placed on a sieve to separate the thin white from the thick. The apparatus used in doing this was similar to that used by Holst and Almquist (1931), and it consisted of two parts, a Petri dish and a perforated sieve 4 inches in diameter, 16 holes to the square inch, each hole, one-eighth of an inch in diameter. The separating sieve was placed on the dish and the whole albumen was poured into it. The thin albumen ran through quite rapidly while the thick remained on the sieve in a thick upstanding viscous mass. The thin and the thick albumen were weighed separately and their volumes were measured in a graduated cylinder.

From table 2 it may be seen that lot 1 (grain and 4-3-1-2 mash) produced eggs having the smallest amount of albumen and lot 3 (all-mash) had the largest. The amount of albumen in lot 1 was 22.518 ± 0.082 grams; in lot 2, 23.038 ± 0.102 grams; in lot 3, 23.092 ± 0.092 grams and in lot 4, 22.747 ± 0.082 grams. A statistical study of the results showed that lot 1 had significantly smaller amount of albumen than either lot 2 or 3, but when compared with lot 4 (molasses) the difference obtained was not significant. It was also observed that there were no significant differences between lots 2, 3 and 4. The difference between lots 1 and 2 were 0.520 ± 0.130; between lots 1 and 3, 0.574 ± 0.120; between lots 1 and 4, 0.229 ± 0.115.

Considering the relative proportion of albumen in the egg, it was found that there was a relatively lower percentage of albumen in the eggs from lot 1 (grain and 4-3-1-2 mash) than in lots 2, 3 and 4. In lot 1, the albumen was 52.57 per cent of the egg; in lot 2, 53.10 per cent; in lot 3, 54.44 per cent; and in lot 4, 54.86 per cent. It may be seen that although there was no significant difference in the weight of albumen in lots 1 and 4, the proportion of albumen in the eggs in the molasses-fed lot, lot 4, was greater than in lot 1 because of the difference in the size of the eggs produced in these two lots, lot 1 having produced larger eggs than lot 4.

From table 2 it may be seen that lot 2 produced the smallest amount of thick albumen and lot 4 (molasses) produced the largest. Comparing all the lots studied, it was found that lots 1 and 2 (grain and mash) produced smaller amounts of thick albumen than the all-mash fed lots (lots 3 and 4). When the two grain-fed lots were compared, lot 1 was observed to produce a larger amount of thick albumen, the difference being 0.625 ± 0.124. When the two all-mash-fed lots were compared the difference observed was insignificant being only 0.006 ± 0.117. When the percentage of the thick in the total albumen was determined, it was found that the eggs from lot 2 had a lower percentage of thick albumen in the total albumen than those in lots 1, 3 and 4. In lot 1 the thick was 63.85 per cent of the total albumen; in lot 2, 59.69 per cent; in lot 3, 63.93 per cent; and in lot 4, 64.92 per cent. These results show that the percentage of thick albumen in lot 2 was apparently lower than in the other three lots. A careful study of the feeds given to the different lots shows that the amount of copra meal in lot 2 was only 5 per cent while in the other three lots (lots 1, 3 and 4) the amount was as much as 15 per cent of the ration. The difference may have been due to copra meal which may have improved the quality of the albumen as thick albumen seems to be more preferred than thin or watery albumen.

Color of the albumen. While the thin albumen was still in the graduated cylinder its color was classified into three groups; namely, light, medium and dark. To classify the color as accurately as possible, color patterns were used for comparison. "Light" is represented by Albus, "medium" represented by Straw Yellow, and "dark" is represented by Light Sulfur-Yellow. The colors of the thin and the thick albumen were studied separately.

Considering the color of the albumen, it may be seen from table 4 that 56 per cent of the albumen in lot 1 was light sulfur-yellow, 39 per cent straw-yellow and only 5 per cent approached "Albus" or clear with slight turbidity. In lot 2, fed with whole corn, 51 per cent of the albumen was light sulfur-yellow, 45 per cent straw-yellow and only 4 per cent light. The all-mash fed lots, lots 3 and 4, produced a decidedly lighter color in the albumen than the other two lots, lots 1 and 2. In lot 3 (all-mash), only 4 per cent was light sulfur-yellow, 64 per cent of the albumen produced was straw-yellow, and 32 per cent was light. The molasses fed lot, lot 4, had albumen that was decidedly light. A careful study of the results shown in tables 3 and 4 will show that the color of the albumen followed the general trend of the yolk color.

A minor observation. In the course of the observations, it was observed that lot 4 (molasses) produced some eggs with traces of blood on the yolk. As a similar condition was not observed in the other lots, it is possible that inclusion of molasses in the ration might have caused some kind of disturbance in the body of the birds. A further study on this subject will be necessary to prove or disprove this supposition.

SUMMARY AND CONCLUSIONS

The results of this study on the effects of whole corn, copra meal, ground corn and molasses as feeds, on the physical qualities of new-laid Los Baños Cantonese eggs may be summarized as follows:

1. The rations tested did not materially affect the color and texture of the shell.

2. Corn when fed to layers in the form of grain produces heavier and larger eggs than when it is ground and mixed with the mash.

3. When whole corn is fed to layers in the form of grain, the specific gravity of the eggs produced is higher and the angle of inclination of the eggs when submerged in water is lower than when an all-mash ration is used.

4. When whole corn is fed to layers in the form of grain, the air cell of the eggs produced is smaller than when the same feed is ground and mixed with the mash.

5. The ration does not materially influence the weight of the shell.

6. The weight of the shell of the Los Baños Cantonese breed of chickens is 4.811 ± 0.0209 grams and is 0.305 millimeter thick at the tip, 0.319 millimeter at the middle and 0.304 millimeter at the butt.

7. Yellow corn when fed whole to layers in amounts consisting of one-half of the ration produces dark-colored yolk, but when the same amount of corn is ground and fed with the mash, the color of the yolk is medium. It is likely that corn, when ground, loses a considerable amount of its xanthophyll.

8. Molasses when incorporated in the ration for layers produced eggs with small, weak and light colored yolk.

9. Grain and mash rations produced eggs with heavier and larger yolks, while all-mash rations produced eggs with lighter, smaller and weaker yolks.

10. The yolk of eggs laid by the Los Baños Cantonese pullets weighs 13.253 ± 0.1686 grams, representing 31.21 per cent of the whole egg.

11. The albumen in eggs of Los Baños Cantonese pullets weighs 22.805 ± 0.0876 grams, representing 53.74 per cent of the whole egg.

12. An all-mash ration has the tendency to produce a higher percentage of albumen.

13. Copra meal tends to produce eggs with albumen that has a large proportion of thick to thin in the total albumen.

14. The color of the albumen as well as the color of the yolk, is, probably, influenced by the pigment present in the ration.

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TABLE 1

Texture and color of the egg shell

LOTS	NUMBER OF EGGS STUDIED	TEXTURE			COLOR		
		Good	Medium	Poor	Brown	Light-brown	Tinted
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
Lot 1	400	27.75	50.50	21.75	11.25	65.00	23.75
Lot 2	383	31.59	47.52	20.89	10.45	73.89	15.66
Lot 3	391	22.26	55.24	22.50	12.03	73.40	14.57
Lot 4	386	20.99	49.48	29.53	14.77	64.50	20.73

TABLE 2

Effects of feeds on the different physical qualities of eggs

PHYSICAL QUALITIES	LOT 1 (Grain and 4-3-1-2 mash)	LOT 2 (Grain and 6-1-1-2 mash)	LOT 3 (All mash)	LOT 4 (Molasses)
Weight of the egg in grams	42.832 ± 0.120	43.383 ± 0.156	42.414 ± 0.128	41.462 ± 0.109
Volume of the egg in cc.	40.195 ± 0.114	42.684 ± 0.141	40.112 ± 0.119	39.005 ± 0.113
Specific gravity of the egg	1.0708 ± 0.0003	1.0665 ± 0.0005	1.0565 ± 0.0006	1.0594 ± 0.0005
Angle of inclination in degrees	9.753 ± 0.057	9.956 ± 0.056	10.717 ± 0.056	11.033 ± 0.056
Height of the air cell in cm.	0.1200 ± 0.0005	0.1240 ± 0.0005	0.1270 ± 0.0007	0.1205 ± 0.0006
Diameter of the air cell in cm.	1.1537 ± 0.0004	1.1513 ± 0.0004	1.1965 ± 0.0005	1.2038 ± 0.0005
Air cell index	0.1033 ± 0.0003	0.1066 ± 0.0004	0.1058 ± 0.0004	0.1062 ± 0.0004
Weight of the shell in grams	4.824 ± 0.0171	4.878 ± 0.0190	4.868 ± 0.0164	4.745 ± 0.0165
Thickness of the shell at tip in mm.	0.304 ± 0.0008	0.305 ± 0.0007	0.305 ± 0.0007	0.3000 ± 0.0007
Thickness of shell at middle in mm.	0.317 ± 0.0010	0.319 ± 0.0007	0.321 ± 0.0007	0.315 ± 0.0008
Thickness of shell at butt in mm.	0.302 ± 0.0007	0.305 ± 0.0007	0.304 ± 0.0007	0.297 ± 0.0007
Thickness of the yolk in cm.	1.821 ± 0.002	1.793 ± 0.003	1.785 ± 0.003	1.787 ± 0.002
Diameter of the yolk in cm.	3.968 ± 0.005	3.934 ± 0.004	3.885 ± 0.004	3.832 ± 0.004
Yolk index	0.4678 ± 0.0007	0.4580 ± 0.0007	0.4591 ± 0.007	0.4606 ± 0.0006
Weight of the yolk in grams	13.795 ± 0.056	13.609 ± 0.047	12.998 ± 0.050	12.712 ± 0.041
Strength of the yolk	37.750 ± 0.930	37.062 ± 0.794	29.015 ± 0.676	20.388 ± 0.556
Weight of thick albumen in grams	14.378 ± 0.087	13.753 ± 0.089	14.763 ± 0.091	14.769 ± 0.075
Volume of thick albumen in cc.	13.957 ± 0.078	13.596 ± 0.084	14.563 ± 0.088	14.567 ± 0.071
Weight of thin albumen in grams	8.305 ± 0.069	9.660 ± 0.082	8.500 ± 0.075	8.037 ± 0.067
Volume of thin albumen in cc.	8.145 ± 0.067	9.502 ± 0.071	8.311 ± 0.078	7.896 ± 0.063
Weight of albumen in grams	22.518 ± 0.082	23.038 ± 0.102	23.092 ± 0.089	22.747 ± 0.082

TABLE 3

Effects of feeds on the color of the yolk

LOTS	NUMBER OF EGGS STUDIED	DARK	MEDIUM	LIGHT
		per cent	*per cent*	*per cent*
1	400	67.75	30.00	2.25
2	383	59.27	36.29	4.44
3	391	5.37	57.29	37.34
4	386	4.46	38.86	56.48

TABLE 4

Effects of feeds on the color of the albumen

LOTS	NUMBER OF EGGS STUDIED	THIN ALBUMEN			THICK ALBUMEN		
		Sulphur yellow	Straw yellow	Light	Sulphur yellow	Straw yellow	Light
		per cent	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
1	400	55.75	38.75	5.50	55.00	39.50	5.50
2	383	50.91	44.65	4.44	50.65	43.86	4.49
3	391	3.59	64.19	32.22	3.83	64.45	31.72
4	386	3.11	26.94	69.95	3.37	27.98	68.65

NOTE: A SIMPLE SELF-ADJUSTING BURETTE[1]

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Of the Department of Agricultural Chemistry

WITH ONE FIGURE

One of the sources of error in volumetric analysis and in all titration work where ordinary burette is used is in adjusting the liquid meniscus at zero. When the level of the eyes is raised or lowered the apparent position of the liquid meniscus is changed. This apparent change of position of the liquid meniscus to which the term *parallax* is applied causes a considerable error in volume reading. With the use of automatic burettes self-adjusting at zero, this source of error is minimized. However, the automatic burettes now in the market are very expensive.

Because of the inherent defect of the ordinary burette, a system of inexpensive, non-fragile, self-adjusting burette was devised. The system is at present in use in our laboratory and is very satisfactory. It is very convenient in our routine analytical work. It operates faster than the usual automatic burette, and minimizes the inherent defect of ordinary burettes. Since it is inexpensive, it is possible to provide one self-adjusting burette for each standard solution. The system showing the details of construction and arrangement is shown in the figure. Stopcock P_1 is grooved by filing it, and the end of the siphon tubing is adjusted with the zero mark of the burette.

The operation of the system is as follows: Air (pressure) is supplied from a suction pump. In the usual automatic burette the pressure is pumped by hand. This source of pressure is very inconvenient when there are many samples to be titrated. Then the air from the suction pump is automatically purified by passing it through columns of baryta water and concentrated c. p. sulfuric acid. To fill the burette open stopcock P_1. When stopcock P_1 is opened the purified air rushes to the reservoir for standard solution driving the solution into the burette. When the solution in the burette has gone beyond zero, stocpcock P_1 is closed. The pressure in the reservoir for standard solution is automatically released to the outside through the groove of stopcock P_1. As the pressure is released the solution beyond zero syphons back to the reservoir for standard solution, and the meniscus reading self-adjusts at zero. Then titration proceeds as in the usual way. After finishing the titration the remaining solution in the burette may be returned automatically to the reservoir for standard solution by opening pinchcock P_3. When necessary, the reservoir for standard solution is automatically filled by gravity by opening pinchcock P_2.

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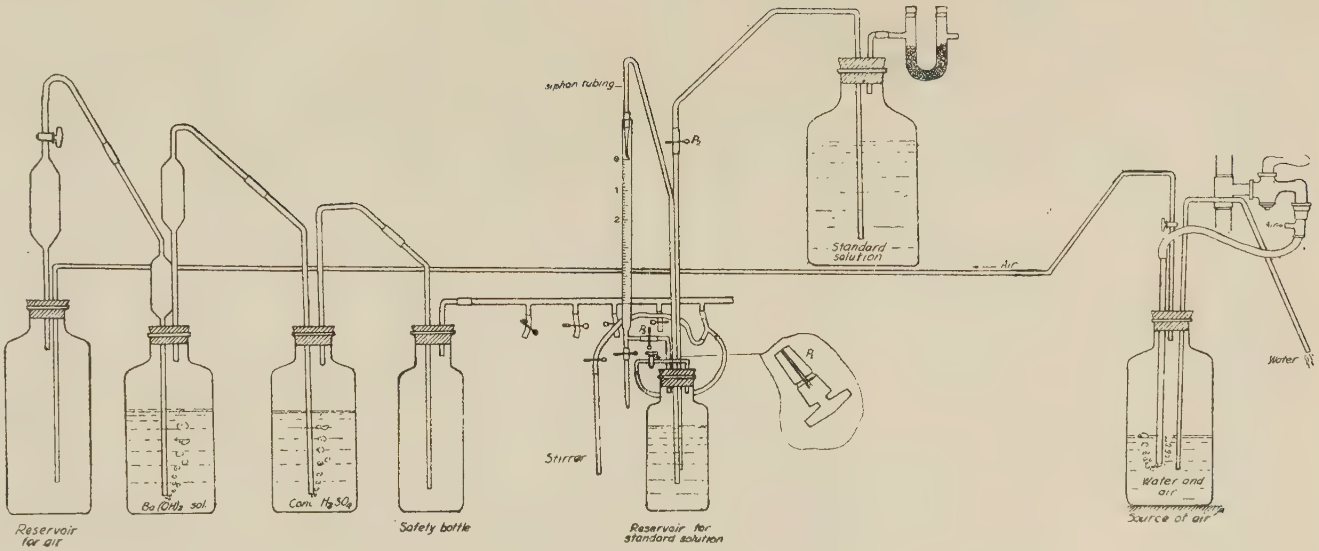
[1] Experiment Station contribution No. 1167.

The system has the following advantages:

1. It is inexpensive and non-fragile.
2. It is self-adjusting at zero as the usual automatic burette.
3. The source of pressure is very convenient. (The pumping by hand as a source of pressure in the usual automatic burette is eliminated in this system). When the pressure is high, the water level in the bottle (source of air) will go down and when the pressure is low the water level will go up. We have found that the pump can go on continuously without bursting the apparatus. When one wishes to use the burette he simply opens stopcock P_1 and the system is on.


siphon tubing
P_2
0
1
2
Standard solution
Air
P_1
Water
Stirrer
Reservoir for air
Ba(OH)$_2$ sol.
Con. H_2SO_4
Safety bottle
Reservoir for standard solution
Water and air
Source of air

Assembly of the self-adjusting burette

PUBLISHED CONTRIBUTIONS OF THE COLLEGE OF AGRICULTURE: XIV[1]

B. M. GONZALEZ
Dean, College of Agriculture

We present herewith a list of the contributions of the College of Agriculture published during the academic year 1936-1937. It cannot but be a source of satisfaction to anyone interested in the progress of science to witness the appearance of this yearly inventory; but to the writer it has meant more than that. It has been a signal honor for him to personally sponsor ten such successive lists. The credit belongs almost wholly to the faculty of the College, who, in spite of repeated and alluring temptations to devote their interest and energies to lines of work that offer greater material returns, have chosen to remain votaries of sciences, patiently dedicated to an obscure task where recognition is rarely obtained and adequate material rewards almost never forthcoming. To the administrator it is a dream come to realization, especially in the face of a prevalent belief that tropical peoples are too depressed by an enervating climate and easy living to be capable of the sustained mental effort which is necessary in the gradual unfolding and interpretation of the facts of science. The record becomes the more noteworthy when one notes the trials to which sister institutions have been subjected under the panacea of reorganization by well-meaning administrators, who see duplication in corroboration; who recognize a clear-cut demarcation line between pure and applied science; who perceive lassitude in the unhurried mind delving quietly into the problem on hand, and who impatient of results would mechanize research so it yield a regular output at the end of every week or month. The College of Agriculture, more or less sheltered by a university charter from extraneous pressure, under a sympathetic president and an understanding governing board, has to a large extent weathered a storm of reform.

The scientific work of the College is now entirely in the hands of nationals. The record being established by the College should be recognized by our statesmen as a palpable demonstration of the fact that our country is capable of producing scientists, but that here, as elsewhere, science must be nurtured under an invigorating atmosphere. And, lest we forget, the words of Andrew Mellon bring back to mind the incontrovertible truth that "Civilization unarmed by science is at a terrible disadvantage in a struggle for existence; and we must realize that this arming cannot be done on short notice".

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[1] General contribution from the College of Agriculture No. 548.

II. EXPERIMENT STATION CONTRIBUTIONS

The contributions are numbered serially as reported. For Nos. 1-199, *see* THE PHILIPPINE AGRICULTURIST XII, No. 7, 1923. For Nos. 200-287, *see* THE PHILIPPINE AGRICULTURIST XIII, No. 10, March, 1925. For Nos. 288-354, *see* THE PHILIPPINE AGRICULTURIST XIV, No. 10, March, 1926. For Nos. 355-440, *see* THE PHILIPPINE AGRICULTURIST XV, No. 10 March, 1927. For Nos. 441-517, *see* THE PHILIPPINE AGRICULTURIST XVI, No. 10, March, 1928. For Nos. 518-595, *see* THE PHILIPPINE AGRICULTURIST XVII, No. 10, March, 1929. For Nos. 596-643, *see* THE PHILIPPINE AGRICULTURIST XIX, No. 2, July, 1930. For Nos. 644-710, *see* THE PHILIPPINE AGRICULIPPINE ARICULTURIST XIX, No. 10, March, 1931. For Nos. 711-799, *see* THE PHILIPPINE AGRICULTURIST XX, No. 10, March, 1932. For Nos. 800-880, *see* THE PHILIPPINE AGRICULTURIST XXI, No. 10, March, 1933. For Nos. 881-948, *see* THE PHILIPPINE AGRICULTURIST XXII, No. 10, March, 1934. For Nos. 949-1021, *see* THE PHILIPPINE AGRICULTURIST XXIII, No. 10, March, 1935. For Nos. 1022-1111, *see* THE PHILIPPINE AGRICULTURIST XXIV, No. 10, March 1936.

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ABSTRACTS [1]

The relation under Los Baños conditions of dates of hatching to the distribution of the first year egg production of Los Baños Cantonese pullets. PABLO C. MACARIOLA. (*Thesis presented for graduation, 1935, with the degree of Bachelor of Science in Agriculture from the College of Agriculture No. 521; Experiment Station contribution No. 1170.*)—The problem of the time of hatching and its relation to egg production which has received the attention of poultrymen in progressive poultry raising countries was the subject of this study. It was made with the hope of providing Philippine poultry raisers with some information as to the proper time of hatching, in order that the pullets may produce eggs during the months when eggs are scarce in the market. The definite object of the experiment was to determine the relation of time of hatching on (*a*) distribution of the first year egg production, (*b*) total egg production, (*c*) egg weight, (*d*) mortality, and (*e*) fertility, hatchability and embryonic mortality of the eggs.

Five lots of Los Baños Cantonese chickens with 27 pullets and one rooster in each lot were used. Lot I was hatched December 2, 1932; lot II, February 2, 1933; lot III, April 2, 1933; lot IV, June 2, 1933; and lot V, August 2, 1933. The pullets were given the same treatment and care.

From this study the author drew the following conclusions:

1. The percentages of egg production were highest in the December hatch and lowest in the April hatch. The August hatch percentage was a little lower than the December. The production of June and February hatches were intermediate between the August and April hatches.

2. The eggs from the June hatch were the heaviest; August hatch, second; April hatch, third; February hatch, fourth; and December hatch, fifth.

3. The December hatched pullets consumed the most feed, followed by the August, February, June, and April hatches. Taken as a whole, the birds consuming the most feed produced the most eggs.

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[1] Abstracts prepared as part of the required theme work in English 3a, College of Agriculture.

4. The cost of feeds to produce one dozen eggs was ₱0.17 for the December, February and August hatches; ₱0.18 for the April hatch and ₱0.19 for the June hatch.

5. The December hatch gave the highest return above the cost of feeds; August hatch, the second; February hatch, third; June, fourth; and April hatch, fifth.

6. The birds in the December hatch at the age of six months had an average weight of 1,017.5 grams; those in the February hatch, 1,276.7 grams; those in the April hatch, 1,189.6 grams; those in the June hatch, 1,034.1 grams and those in the August hatch, 1,054.1 grams. The birds in the December hatch gained the most in weight during the year; those in the August hatch, second; those in the June hatch, third; those in the April hatch, fourth; and those in the February hatch, fifth.

7. In the incubation tests conducted, the highest percentage of hatch was in the August hatched lot; June hatch, second; December hatch, third; April hatch, fourth; and February hatch, fifth.

8. The pullets in the December, February and August hatches appeared to be more vigorous than those in the April and June hatches.

9. Regardless of the time of hatching, the birds tended to produce a high percentage of eggs in the months of February and March. This production, however, was affected by the cycle of egg production which showed a peak in the fourth month after the pullets started laying.

10. The highest mortality was observed in lot III, April hatch, and lot IV, June hatch; the lowest was in lot I, December hatch and in lot V, August hatch; the February hatch, lot II, stood intermediate.

—Abstract by Victoriano J. Madrid

Field tests in the Philippines of four varieties of Vigna sinensis (Linn.) Savi. FELIPE T. AALA. (*Thesis presented for graduation with the degree of Bachelor of Agriculture, 1933, from the College of Agriculture No. 520; Experiment Station contribution No. 1169.*)—The objects of this work were: (*a*) To compare the yield for the dry and the wet season cultures of each of four different varieties of cowpea; (*b*) to compare the four varieties as to yield; (*c*) to study the characteristics of the four varieties; and (*d*) to find out what insect pests attack them.

The four varieties used were White, Gray, Black, and Brownish Red. These are the most common varieties in the Philippines. The Brownish Red variety is not raised commercially.

The land which was plowed and harrowed three times with native implements was divided into lots. In both the wet and the dry season cultures, 12 lots of 100 square meters each were planted. There were 12 rows in each lot and the distance of planting was 50 by 80 centimeters; 3 seeds were planted to a hill.

Observations were made on the plants during their growth. The size of the plants, their creeping habit, their flowering and the maturity of the fruit were noted. Insect pests attacking the plants were also observed and studied.

The following results were obtained:

(1) Plants flowered earlier in the dry season than in the wet. In the dry season the increase in the production of seeds was proportional to the increase in the production of vines.

(2) The Black variety had the highest percentage of germination in both the wet and the dry season cultures. This variety grew more vigorously in the wet season culture than the other three varieties tested, and it had the largest seeds.

(3) The White variety was the most prolific in seed production in both the wet and dry seasons. Its average yield of seeds per hectare was 299.51 kgm. in the wet season culture; this was the highest yield of any variety. It ranked highest in vine production in the dry season, but lowest in the rainy season. Of the four varieties this variety was the most resistant to drought.

(4) The Brownish Red variety was the highest in the production of vines in the wet season, but in production of seeds it ranked second to the White variety.

(5) All the four varieties tested have a creeping habit of growth in the wet season culture. In the dry season, only the White variety has this habit; the other three varieties have erect stems.

(6) The White variety has white flowers. The blossoms of the three other varieties are violet in color.

(7) The most serious insect pests found were: *Aphis laburni* Kaltenbach, *Phaneroptera furcifera* Stal., *Nezara viridula* Linn., *Riptortus pedestris* Fabr., and *Heliothes obsoleta* Fabr.

The author recommends the White variety for planting on commercial scale in both the wet and the dry seasons.

—*Abstract by Martiniano E. Rosell*

COLLEGE AND ALUMNI NOTES

Among the attractions at the 1937 Philippine Exposition in Manila were the entries of the College of Agriculture which included, among numerous other items, a detailed exhibit showing a newly devised method of ham making without the aid of refrigeration, the recently developed rice hybrid—Ramelon, and straight alcohol actually in use as a highly efficient fuel for different makes of automobile and truck engines.

Dr. Murray Bartlett, first president of the University of the Philippines, visited the College on January 29, where he spoke at a convocation before an enthusiastic group of faculty and students. A military parade was held in his honor by the local units of the R.O.T.C. in the afternoon and a faculty dinner followed in the evening. Before leaving the following day, Doctor Bartlett made a tour of inspection of the classrooms, laboratories, and farms.

Mr. Marcelo Crisostomo, '13, visited the College on February 8 for the first time since his graduation twenty-four years ago. He was accompanied by Mrs. Crisostomo and his many children, including a married son. Mr. Crisostomo has his present home in Iloilo, where he is a prosperous farmer.

The following papers were read at the meeting of the Los Baños Biological Club on January 28:

Dr. José M. Capinpin. Studies on biotypes of Philippine corn.

Mr. Engracio Basio. Observations on pigmentation of Los Baños Cantonese pullets.

Dr. N. B. Mendiola. A search for hidden and traumatic bud variations in sweet potato.

The honorary Society for the Advancement of Research recently elected to active membership Dr. Felipe M. Salvoza, of the School of Forestry.

Under the auspices of the Department of Agricultural Education of this College, the second annual public speaking contest for students of agriculture in the Philippines was held in the College auditorium in the evening of January 22. Entries were sent by Batac Rural High School, Batangas High School, Lagangilang Agricultural High School, Luis Palad High School, Pampanga Agricultural High School, Tarlac High School, and U. P. Rural High School. The winners were: first prize, Mr. Fidel Manalo, of Batangas High School; second prize, Mr. Abelardo Dolendo, of Luis Palad High School; and honorable mention, Miss Nenita Valdez, of Batac Rural High School. The prizes consisted of a gold and a silver medal donated by the Calamba Sugar Estate and a silver cup donated by Don Sixto Lopez, the last to be awarded permanently to the school winning it three times. *The Philippine Agriculturist* gave each contestant a complimentary one year's subscription to this paper.

A party of faculty members, consisting of Dean B. M. Gonzalez, Dr. N. B. Mendiola, Dr. F. M. Fronda, and Dr. Miguel Manresa, visited the Central Luzon Agricultural High School at Muñoz on January 6.

Through the courtesy of the Weather Bureau, the College of Agriculture has been included, beginning the latter part of December, 1936, in the Manila Observatory's typhoon-warning service. Telegraphic reports are sent to the College of typhoon signals as these are hoisted in Manila.

The permanent faculty committee for the Baker Memorial Scholarship has made the 1937 award to Mr. Amando M. Dalisay. Mr. Dalisay was on the honor roll of the College on four occasions: first semester, 1933-34; second semester, 1934-35; second semester, 1935-36; and first semester, 1936-37. Before entering College, he had been the valedictorian of the class of 1933 in the U. P. Rural High School. He has been a self-supporting student, having worked first as a student assistant in the College library and subsequently in the Department of Agricultural Economics. He is at present the Student Body representative to the *Philippine Collegian*.

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